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Construction of the Maiden Creek Slow Sand Water Filters for Reading, Pa.

By MANDES GOLDER.*

The design of the Maiden Creek Filters was described in Engineering News of April 13, 1910, in connection with an article on Increasing the Filtered Water Supply of Reading, Pa.

The work consisted of excavating for and building ten filter beds, an operating-house, raw-water conduit, piping and appurtenances.

EXCAVATION.—The excavation consisted of about 60,000 cu. yds. of earth and about the same amount of limestone rock and limestone boulders. The earth was removed by several methods, depending upon the length of haul, most of the top soil was loaded into dump cars by means of a plow grader and then hauled to a storage pile, using traction engines as motive power for both the plow and cars. Teams and dump wagons were sometimes used instead of dump cars. For short hauls and for covering filters, wheel scrapers were used. For long hauls, a small steam shovel loaded dump wagons, which hauled the earth to the fill.

The limestone rock and boulders were treated according to their intended use. During the construction of the retaining wall, an effort was made to save good building stone. After the completion of the wall, it was desired to break all the stone to a size fitting the stone-crusher. Surplus stone was loaded into cars and taken to a dump across the creek. The building stone was loaded on flat wagons and hauled to place by teams. The crusher stone was loaded into boxes, hoisted by traveling hoists into 3-yd. dump cars and hauled directly to the crusher or to the dump. All rock drilling was done by compressed air. In preparing foundations in the limestone cut, the contractor found it cheaper to dig below the required depth and raise the footings and floor blocks with concrete and fill between these to the floor level with limestone screenings than to prepare the irregular bottom, as shown on the original plans. The footings in earth cut were at first prepared to grade, as given on plan. It was, however, found necessary to carry all footings to loose rock foundation. This was made necessary because of the near proximity of the creek, which at certain times of the year would raise the water level in the earth foundations, thus weakening them and causing settlement of masonry.

CONCRETE.—All concrete for the filter construction (about 15,000 cu. yds.) was of 1:2:4 mixture. The concrete was mixed in a ⅔-yd. Haines gravity mixer. The crusher, mixer, sand bins and derrick were so located that only one hoist was necessary to deliver the materials to the mixer. The mixer was located in back of the filters and at such an elevation which allowed the concrete cars to run by gravity to the work. Three-quarter-yard steel dump cars were used to haul the concrete to the work. All side wall and end wall forms, with a few exceptions, were filled by dumping from the car directly into the forms, thus saving double handling. In filling the piers, floor blocks and floor slabs, two sets of dump cars were used. One set brought the concrete from the mixer and dumped it down through shutes into a car on the floor elevation, which carried the concrete where desired. In covering the roof, the cars were run directly on top of the forms and the concrete distributed as desired. On account of the irregularity of the foundations, it was found convenient to raise all footings to Elevation 247.15 (bottom of floor), and then set the wall and pier forms on the prepared concrete footings. In constructing the 5-ft. reinforced-concrete conduit, it was found impracticable to use the ¼-in. to 1-in. stone as specified. Instead, a mixture of 1 part cement, 1½ parts sand, and 3 parts ¼-in. stone, mixed wet, was used for the invert. For the crown, the regular 1:2:4 mixture was used. The difficulty was caused by the close spacing of the reinforcing bars, and the fact that the conduit was built almost entirely in cut, making it difficult to thoroughly tamp the concrete. The reinforcing bars were spaced as follows: ⅝-in. sq. longitudinal bars on 7-in. centers; ½-in. sq. transverse bars on 8-in. centers. Blaw collapsible steel forms resting on prepared concrete blocks were used in the construction of the conduit.

VIEW SHOWING CONSTRUCTION WORK ON THE CONCRETE PIERS AND ROOF VAULTING OF THE MAIDEN CREEK WATER FILTERS, READING, PA.

FORMS.—The wall forms, as shown on the original plans, were found strong enough while wheeling or shoveling the concrete into them. After the direct dumping was started, the forms bulged between supports. The roof forms, as originally designed, were found entirely satisfactory. In plugging the cracks in the forms to make them watertight, cement mortar was tried, but found expensive. A paper covering was tried on the vaulting of one of the beds, but was found unsatisfactory on account of sticking of the paper to the concrete. The paper could only be removed by wetting and scraping with wire brushes. Slacked lime was finally adopted and found uniformly satisfactory. A more satisfactory concrete, and undoubtedly at a less cost, would have been attained had tongued and grooved lagging been used. Lehigh Portland cement was used for the construction of the filters.

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Tests of Nickel-Steel Details for the Board of Engineers, Quebec Bridge.

In preparing to design the new Quebec Bridge, the Board of Engineers, which has the matter in charge for the Canadian Government, contemplated from the first the use of nickel-steel in the main members as a means of reducing the enormous dead-loads by virtue of the higher stresses which this material permits. It was thought necessary, however, to obtain definite test figures on the strength of nickel-steel riveting before designing the riveted details, and also to verify the proportioning of the compression members by actual test. For this purpose, two extensive series of tests were made. The first series covered a

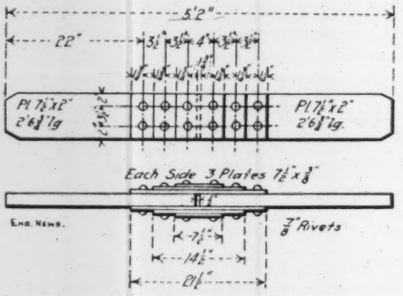


Fig. 1. Sketch of Test-Piece for Cyclic Stress Tests of Nickel-Steel Riveted Joints.

large number of riveted splices, both lap and butt, with different thicknesses of plate packing, for comparison with prior tests of carbon steel rivets. For the special purpose of comparing unidirectional and alternating stress, it included 16 riveted splices of identical construction, each test-piece having six ⅞-in. rivets in double shear on either side of the splice. The tests included not only the determination of ultimate shearing strength and slipping point under unidirectional stress, but the more important factor of cyclic deformation under conditions of reversed or alternating stress. The other series of tests was made on models of the principal compression members designed for the bridge. On account of the fact that the largest testing machine available for compression tests has a capacity of only 2,500,000 lbs., full-size members could not be tested. Models were therefore built in reduced size to a scale varying from ⅛ to ¼ linear dimension, or 1/9 to 1/16 area of cross-section. These models were tested in the testing machine of the Phoenix Iron Co. at Phoenixville, Pa. The results of both series of tests are given in the following article.

Tests of Nickel-Steel Riveted Joints with Special Reference to Alternating Stresses.

These tests were made for the Board by Profs. A. N. Talbot and H. F. Moore at the University of Illinois, Urbana, Ill.

The large majority of the test-pieces was tested in simple tension, and we may summarize the results of these tests briefly as follows:

1. The ultimate strength of the nickel-steel joints, per square inch of rivet-shear area, was generally somewhat higher than that of corresponding joints of ordinary structural steel. The excess of strength ranged from 10% to 20%, and for the whole series averaged about 15%.

2. The ultimate strengths ranged from 45,000 to 50,000 lbs. per sq. in. of rivet-shear area for the ordinary steel joints, and from 52,000 to 60,000 lbs. for the nickel-steel joints.

3. The strength of the joints with long rivets was somewhat lower than that of the joints having short rivet-grip. The average difference between the extreme forms was only about 5%, however.

4. The joints showed beginning of slip at about the same load per rivet, the nickel-steel joints showing slightly higher resistance. In both kinds of joint the first slip occurred at loads close to 10,000 lbs. per sq. in. of rivet-shear area.

As the first slipping occurred at very low load, tests were undertaken to investigate the relation of this phenomenon to repeated and alternating stresses. These tests are reviewed somewhat fully in the following.

The form of test-piece is shown by Fig. 1. Sixteen such specimens were built, all identical, with the one difference that eight were riveted with a hydro-pneumatic pressure machine and eight with a pneumatic hammer so as to represent the conditions of shop riveting and field riveting respectively (denoted by S and F in Table II.) It happens that the results indicate no recognizable difference in strength between the two kinds of riveting; if anything, the "field" rivets gave slightly higher results than the others.

The rivets as well as the plates were of nickel-steel, the dimensions of all parts being given in Fig. 1. The composition and physical test qualities of the material are stated in Table I:

TABLE I.—QUALITIES OF NICKEL-STEEL FOR RIVETED-JOINT TESTS.

PLATES—(Composition: C, 0.282%; Mn, 0.69%; Ni, 3.24%; P, 0.007%; S, 0.024%.)

Tensile Strength. Yield-point, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	Elongation.	Reduction of area,	Shearing Strength. (Ultimate; test piece ½-in. sq.) lbs. per sq. in. Single Shear	Double Shear
56,130	84,370	20% (in 8 ins.)	47.9%	66,370	64,120

RIVET ROD—(Composition: C, 0.126%; Mn, 0.41%; Ni, 3.29%; P, 0.010%; S, 0.022%.)

44,960	68,450	33.5% (in 2 ins.)	63.4%	....	....

All material was painted with a coat of graphite paint before being riveted together.

PROGRAM OF TESTS.—The tests in simple tension and simple compression, respectively, furnished a basis for gaging the effect of stress reversal. The alternating-stress tests included some modifications in the sequence of alternations and magnitude of stresses, and in two tests provision was made for measuring the bending of the rivets. The following schedule states the nature of the several tests:

(A) Pure tension, three specimens, Tests 99, 100, 101. Load applied in stages of 25,000 lbs. (equivalent to 3,500 lbs. single-shear stress on the rivets) and released after each application so that the permanent set could be measured.

(B) Pure compression, three specimens, 102, 103, 104. Same sequence as in tensile stress.

(C) Stress reversal, two specimens, 95, 97. Cyclic loading, principal load tensile followed in each load-stage by a compression half as great. Cycles of progressively higher intensity.

(D) Alternating stress, eight specimens. Cyclic loading, tension and compression equal. Cycles of progressively higher intensity in 5 tests and certain repetitions in 3 tests. The deformation was measured at each stage of loading in each

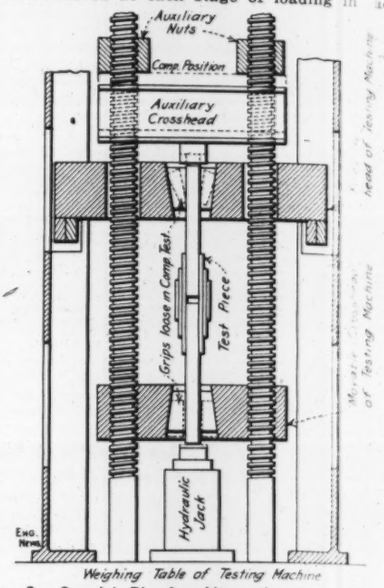
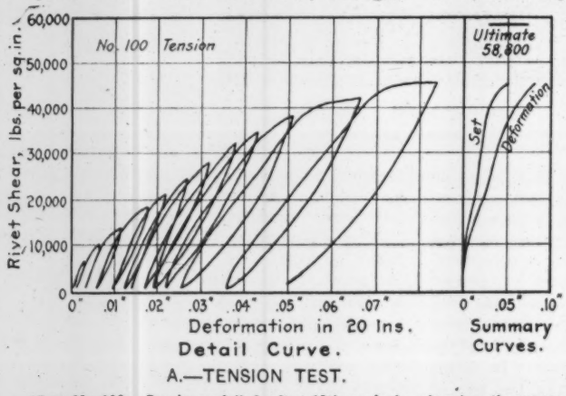


Fig. 2. Special Rig for Alternating-Stress Tests, as Fitted to the 300-ton Screw-Power Testing-Machine at University of Illinois.

cycle. In Tests 91, 92 and 96, under progressive loading, the test-pieces were unchanged. In tests 94 and 98 holes were drilled longitudinally through the rivets and observations made at different loads to determine the amount of bending of the rivets. One test (93) with five repetitions of all cycles at low stages of loading. Two tests (105, 106) were in effect tests of repetitive alternate loading, and consisted of repeated tension-compression cycles of a rivet-shear value of 10,000 lbs. per sq. in., with an occasional cycle of higher intensity interposed, as follows:

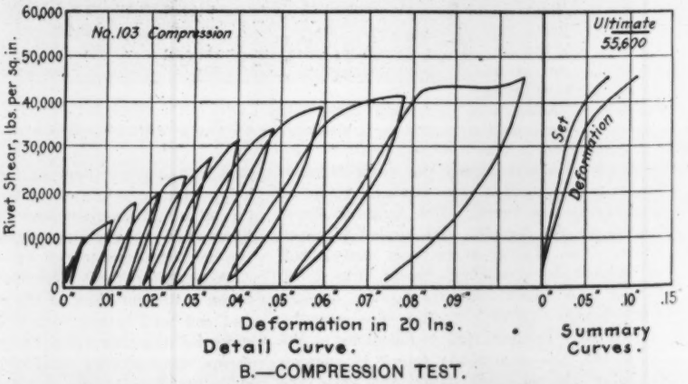
10 cycles	10,000 lbs.
1 cycle	15,000 lbs.
10 cycles	10,000 lbs.
1 cycle	20,000 lbs.
10 cycles	10,000 lbs.
1 cycle	25,000 lbs.
1 cycle	10,000 lbs.
34 cycles.	

In all tests but the last two, the loading for deformation measurement was carried to a total load of about 300,000 lbs., or about 42,000 lbs. per square inch of rivet-shear area; and in the last two tests the maximum rivet-shear was 25,000 lbs. per sq. in. Dial extensometers indicated the deformations. After the stated loading, the instruments were removed and the piece tested to fail-



A.—TENSION TEST.

(Test No 100. Specimen failed after 13th cycle by shearing the upper side of six rivets, at a shear stress of 58,800 lbs. per sq. in. on the rivets.)



B.—COMPRESSION TEST.

(Test No. 103. Specimen failed after 13th cycle by shearing the lower side of the rivets, at a shear stress of 55,600 lbs. per sq. in. on the rivets.)

FIG. 3. TYPICAL TEST-CURVES FOR UNIDIRECTIONAL STRESS; RIVETED JOINTS OF NICKEL-STEEL.

ure; this final test was *tensile* in all cases except the three compressive tests. In the latter the loading was kept compressive, but only one gave a true failure, the other two tests terminating when the main plates came into contact at the center (the original space here was ½-in.).

In none of the tests did either the main plates or the splice covers reach their elastic limit when the plates failed. All failures occurred by rivets shearing off. In some cases the rivets on one side only sheared, while in others the rivets on both sides of the joint sheared off. Failure was accompanied by a loud report, and the load fell off slightly just before failure.

The tests were made in the 300-ton screw-power Riehle machine of the University of Illinois. While this machine can test either in tension or in compression, special equipment was needed in order to change from one stress to the other without shifting the specimen. The machine was therefore modified as shown in Fig. 2. The auxiliary crosshead above the fixed weighing crosshead was added to take the upward reaction in compression, and a hydraulic jack was set on the weighing table to provide the power for compression; the pressure exerted by the jack was weighed directly by the machine. For tension testing these parts were out of action, and the specimen was held in the regular crossheads by wedge grips. Little manipulation was required to loosen or drive the wedges in changing from one kind of stress to the other.

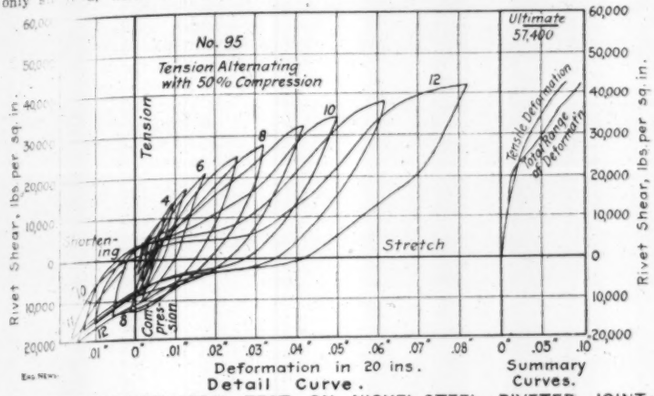


FIG. 4. STRESS-REVERSAL TEST ON NICKEL-STEEL RIVETED JOINT; MAIN STRESS TENSILE; COMPRESSION IN EACH CYCLE HALF AS GREAT AS THE TENSION.

(Test No. 95. Tested to failure in tension after the reversal test. Ultimate rivet-shear 57,400 lbs. per sq. in.)

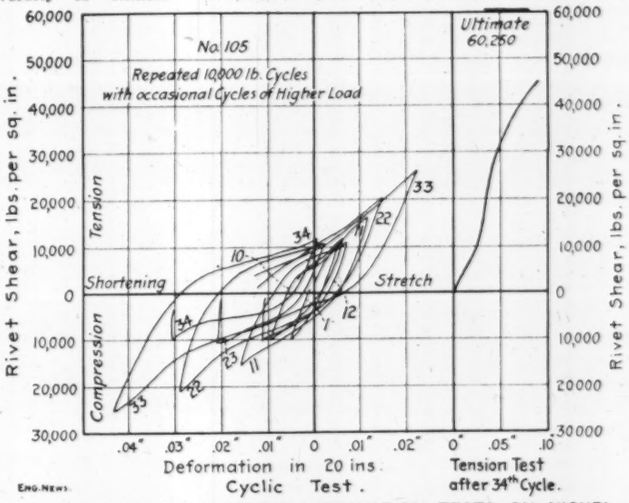


FIG. 7. REPETITIVE STRESS-ALTERNATION TESTS ON NICKEL-STEEL RIVETED JOINTS. TENSION AND COMPRESSION EQUAL.

(Test No. 105. Normal cycles of 10,000 lbs. shear value; 11th, 23rd and 33rd cycles of higher intensity. Note effect of higher-stress cycles in increasing the deformation in the subsequent normal cycles. After 34th cycle the specimen was tested to failure in tension. Ultimate rivet-shear 60,250 lbs. per sq. in.)

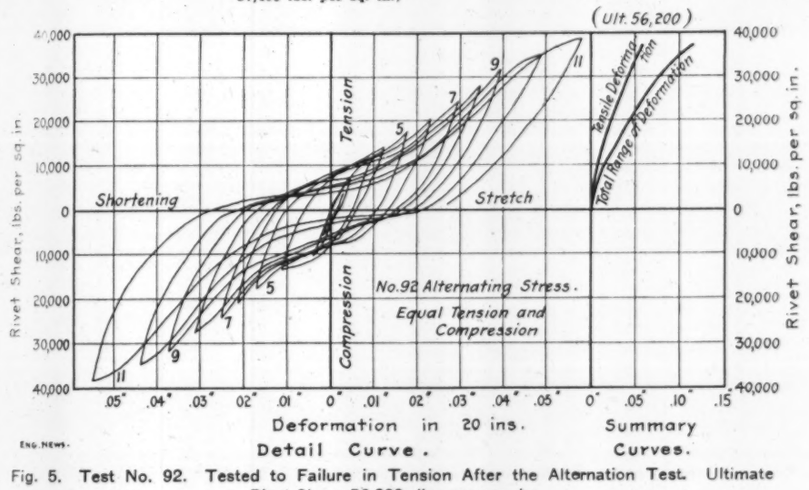


Fig. 5. Test No. 92. Tested to Failure in Tension After the Alternation Test. Ultimate Rivet-Shear 56,200 lbs. per sq. in.

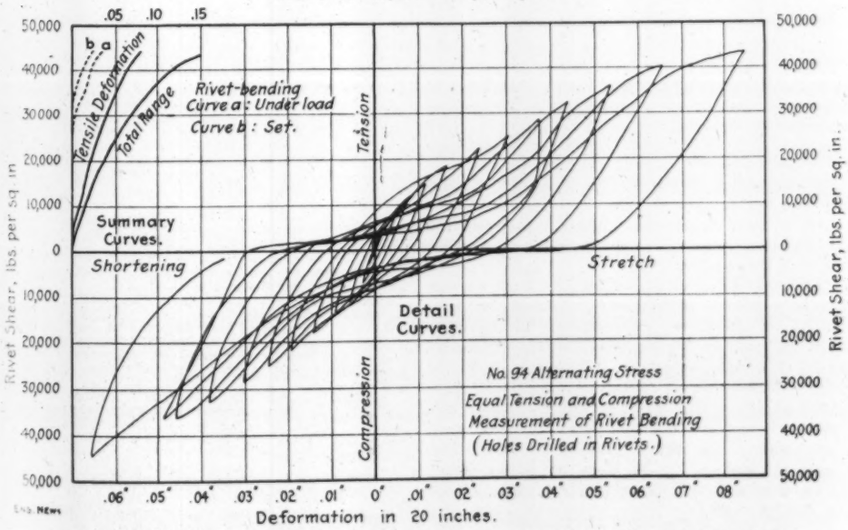


Fig. 6. Test No. 94. Holes Drilled in Rivets to Observe Bending of Rivets. Bending Curves Included in Summary Curves at Left. Tested to Failure in Tension After the Alternation Test. Ultimate Rivet-Shear 57,550 lbs. per sq. in.

FIGS. 5 AND 6. PROGRESSIVE STRESS-ALTERNATION TESTS ON NICKEL-STEEL RIVETED JOINTS. TENSION AND COMPRESSION EQUAL.

The machine applied load at a stretch rate of 0.4-in. per minute. The extensometers read to 0.0001-in. In computing the results, rivet-shears were based on the sectional areas corresponding to the nominal diameter of the rivets before driving.

In testing for bending of rivets, holes of 0.204-in. diameter were drilled through all rivets of the joint as near axially as possible. A series of Stubs drill-rod pieces was provided, varying in diameter from 0.180 to 0.204-in., by steps of about 0.003-in. Under the initial load the largest drill-rod that could be thrust through the hole was determined by trial. At each load stage the drill-rods were again tried, and the largest that would go through was determined. The difference between this and the initial rod gave the amount of bending at that load.

The results of the tests are typified by the curves reproduced in Figs. 3 to 7 herewith, and in Table II., which gives the ultimate shearing strength, the yield point and the deformation at the yield point.

RESULTS.—The ultimate strength of the rivets proved to be remarkably constant, and unaffected by the prior stressing of the joint. From Table II., the values range from 55,200 to 60,250 lbs. per sq. in. shear area. The ten joints subjected to reversal of stress averaged 57,250 lbs., and the three joints subjected to pure tension averaged 57,900 lbs., which values are substantially identical.

The yield-points cannot well be compared, since no marked yield-point appeared. The values given are the stresses at which the rate of deformation was 50% greater than the initial rate. However, as selected in this way the values for the cyclic stress tests are about equal to those found in pure tension or compression.

The significant feature of the deformation measurements made under unidirectional stress is that "set," i. e., rivet-slip, appeared at very low loads, usually at rivet-shears as low as 10,000 lbs. per sq. in. Test 100 is representative of the three tension tests in this respect, and Test 103 of the three compression tests. The cyclic stress tests, of course, did not give any "set" indications. However, as Fig. 3 shows that the beginning of set coincided with a perceptible deflection of the de-

TABLE II.—RESULTS OF TESTS OF NICKEL-STEEL RIVETED JOINTS.

For Board of Engineers, Quebec Bridge. Made at University of Illinois by Profs. A. N. Talbot and H. F. Moore.

No. of Test.	Riveting.	Yield-point. Rivet Shear, lbs. per sq. in.	Yield-point. Range of Deformation, ins. [Set ins.]	Ultimate Strength. Rivet Shear, lbs. per sq. in.
A.—Tension Only.				
99	S	34,000	0.050 [0.030]	56,700
100	F	36,100	0.041 [0.023]	58,800
101	S	34,600	0.045 [0.028]	58,100
B.—Compression Only.				
102	F	37,000	0.033 [0.020]	.....*†
103	S	33,700	0.045 [0.030]	55,600*
104	F	35,600	0.035 [0.020]	.....*‡
C.—Stress Reversal: Cyclic loading, compression half as great as tension.				
95	S	39,000	0.079	57,400
97	S	38,900	0.095	55,200
D.—Alternating Stress: Cyclic loading, compression equal to tension.				
91	S	31,800	0.088	55,800
92	S	33,800	0.089	56,200
96	F	36,400	0.092	57,700
Same; holes drilled in rivets to observe bending.				
94	F	36,500	0.100	57,600
98	F	36,600	0.085	58,300
Same; without holes; five cycles at each stage of loading.				
93	S	34,800	0.095	56,600
Same; repetition of normal cycles of 10,000 lbs. shear, with occasional higher cycles.				
105	F	32,700	0.052§	60,300
106	F	30,300	0.045§	57,600

*Compressive test. All other tests to rupture were in tension.
†Ends of main plates came together.
‡Joint buckled and ends of main plates came together.
§Range of deformation in tension.

formation curve, it is fair to conclude from the summary curves of Figs. 4 to 7 that the corresponding phenomena appear at the same or even lower load. Moreover, the cyclic curves in Figs. 4 to 7 demonstrate clearly that the principal motion in each cycle occurred at a load *well below* 10,000 lbs. per square inch of rivet. This is most noticeable in the tests under relatively high loading, where the main part of the motion often took place under a shearing stress as low as 4,000 lbs. per sq. in.

The effect of stress reversal in causing a progressive loosening of the joint is quite apparent from these cyclic curves. Comparing Figs. 5 and 6, it does not seem that the holes drilled in the rivets increased the cyclic yield; and, as Table II. shows, they did not weaken the rivets against shearing failure. The curves of Figs. 5 and 6 may therefore be grouped together. Comparing them with the curves of Fig. 4, in which the compression remains relatively low instead of being carried as high as the tensile stress, it may be concluded that the total range of deformation for a given total range of stress is the same whether the range of stress is equally divided between tension and compression or not. The curves are exactly similar, except for their position with respect to the origin and the gradual shifting of the cyclic curves toward the right in Fig. 4. The progressive flattening of the curves corresponding to increasing amounts of inelastic distortion is of the same character in Fig. 4 as in Figs. 5 or 6.

The nature of the inelastic action is further explained by the test summarized in Fig. 7, where cyclic loading of constant intensity was interrupted by an occasional cycle of higher intensity. It will be noted that the first set of ten cycles of 10,000 lbs. per sq. in. shear area already produced a very considerable broadening of the distortion cycle. When this was followed by a 15,000-lb. cycle, however, the subsequent normal cycles, 12 to 21, showed a further broadening. The effect was again increased by the 20,000-lb. cycle, as indicated by the curves for cycle 23, and finally the 34th cycle showed a greatly increased effect as a result of the 25,000-lb. cycle immediately preceding. This test was arranged for the specific purpose of showing what would occur under repeated loading of normal amount when an occasional load-cycle of greater amount might occur in the series. The results prove that the interjected higher loading exerts a very distinct effect in reducing the rigidity of the joint under the subsequent alternations of normal load.

The interesting study of rivet bending by drilling holes in the rivets (tests 94 and 98), summarized in Fig. 6, showed that noticeable bending occurred only at a much higher load than the yield by slipping. Test 94, which is typical for the two, indicates that no bending occurred in the rivets below a rivet shear of 25,000 lbs., and no permanent bend appeared below about 33,000 lbs. per sq. in. shear area.

While these tests afford no means of judging of the effect of a very large number of repetitions or reversals of stress, they prove conclusively that stress reversal produces very marked movements in the joints. Such motions occurring in a structure might alter the distribution of stress through the structure quite materially.

Tests of Nickel-Steel Models of Compression Members.

The column tests were made with the object of verifying the estimates of strength of the compression members of the official or Board design for the new Quebec Bridge, a cantilever design with main span of 1,758 ft. (see Eng. News, April 20, 1911, Fig. 1 on Inset Sheet). This design calls for chord sections exceeding 1,000 sq. ins. maximum, which is about 50% greater than the largest chord section used in the old Quebec Bridge, and in view of the greater strength of nickel-steel represents about three times as strong a column. The general type of member adopted was similar to that in the old structure, comprising four vertical longitudinal ribs connected by lacing, though the new designs had more ample cross-connections of the ribs. But as the material was different—nickel-steel as against carbon-steel—the tests made in 1907 on models of the compression chords of the collapsed bridge did not furnish a basis for fixing the strength of the new members.

Certain other features of the Board design made it desirable to have careful tests of ultimate strength: (1) The large members being enormously heavy, the heaviest of them were for easier erection designed to be made in halves which would be joined in erection. The division of the member was to be made in a longitudinal vertical plane, each half thus consisting of two ribs, with subsequent connection across the middle space by lacing (and in a few cases also cover-plates). The sufficiency of this cross-connection would be shown by the tests. (2) In a few cases, erection loads would be imposed on a half member before the second half could be set and joined up, and it was desired to know the strength of such a section. (3) In some of the members the webs of the ribs called for plates of exceptional size (in one case 95 ins. × 2 ins.), and it was desired to know whether equal results would be secured by using instead of a wide plate several narrower plates side by side held together by cover-strips. (4) The chord panel-point connections being made less rigid by the unavoidable omission of cross connections between the several ribs where the web members enter between, it was not known whether the amount of reinforcing material provided at these points was sufficient to make the panel-points relatively as strong as the other parts of the structure.

TESTPIECES.—Four different compression members of the bridge were selected for test, and one of them was represented in two variations; a half width of one of them was also tested in two variations, making a total of seven different forms of strut. One panel-point added to the series made a total of eight test forms. Two duplicate testpieces of each form were made; the total number of testpieces, therefore, was 16. They were built and tested under contract by the Phoenix Bridge Co., of Phoenixville, Pa.

The Phoenix testing machine, though it is the largest compression-test machine available, has a capacity of only about 1,400 tons. The testpieces had to be made small enough to fall at a load within this capacity. Since the corresponding members of the bridge had estimated strengths ten to twenty times as great as the capacity of the machine, small-scale models had to be built for the tests. The scale of reduction used for most of the test-forms was 1:4, or linear ratio; two required the slightly greater reduction of 1:4.5; and one which permitted larger proportions was made to the linear scale of 1:2 or about 1:2.9. The corresponding area-ratios are 1:16, 1:20.25, and 1:8.463.

The general features of the several testpieces are listed below, in the Schedule of Test Members; the make-up is given in the Table of Test Results. The cross-sections varied from 27.6 sq. ins. to 57.5 sq. ins., and the lengths varied from 20 ft. to 35¾ ft., except that the panel-point models were only 7 ft. long.

MATERIAL.—The material of which the columns were made comprised bars and plates from 2 × ⅛ ins. to 40 × 9/32 ins. and 18¾ × 11/32 ins.; angles from 1½ × 1½ × ⅛ to 3 × 3 × 11/32 ins.; and rivets about 3/16-in. to 11/32-in. diameter. The plates and angles were tested in small-size tension tests, giving average results as follows:

	Plates, over ⅛-in.	Lacing bars, ⅛-in.	Angles, Over ⅛-in.	Angles, ⅛-in.
Elastic limit, lbs. per sq. in.				
Minimum	53,600	67,300	53,800	53,300
Maximum	61,000	68,400	61,100	66,400
Average	58,500	67,800	57,500	63,700
Ultimate strength, lbs. per sq. in.				
Minimum	81,000	90,500	76,500	79,200
Maximum	87,000	91,300	89,500	86,200
Average	84,400	90,900	82,000	83,800
Elongation, % in 8 ins.				
Minimum	20.0	18.8	15.5	16.3
Maximum	23.5	19.5	24.5	18.8
Average	22.0	19.2	22.0	17.8
Reduction of area, %.				
Minimum	41.4	45.1	45.2	37.1
Maximum	50.4	50.6	59.4	52.6
Average	45.9	47.8	54.3	46.6

The chemical analyses showed the material to have the following average composition:

Carbon	0.20%
Manganese	0.41%
Nickel	3.66%
Phosphorus	0.012—0.014%
Sulphur	0.018—0.020%

(Text continued on page 530.)

SCHEDULE OF TEST MEMBERS.

(For make-up see Table of Test Results.)

T_1.—Model (1:4.5 linear) of bottom-chord L12—L14 of the cantilever arm, extending outward from main pier two panels.

Dimensions: 21 7/16 ins. deep at pier end, 20⅛ ins. at outer end; 21⅝ ins. wide c. to c. of outer ribs; 19 ft. 7⅛ ins. long. Consists of four vertical ribs, makeup as given in Table of Test Results. Average cross-section, by weight, 55.8 sq. ins. for T_1 A, 57.49 sq. ins. for T_1 B. Length-ratio, 32.2 around horizontal axis, 30.2 around vertical axis.

Constructional details: Central horizontal diaphragm, 1¼ × 5/32-in. lacing bars in middle space, 1¾ × ¼-in. bars in outer spaces, both attached by four rivets at each end. Top and bottom lacing 1⅛ × ⅛-in., four rivets. Vertical transverse plate diaphragms at intervals of about 4 ft. throughout length, made in upper and lower halves. Pin bearing at pier end, 10-in. pin., with bearing area 55% in excess of body. Flat bearing at outer end, with 33% excess over body. Radial stiffening angles at pin bearing. Shop splice in middle of length.

This chord-section would be the heaviest member in the bridge. On account of its weight the design provided for erection in two longitudinal halves (right and left), joined in the field by riveting rows of lacing in the bottom flange and the central diaphragm, and a cover-plate in the top flange.

T_7.—Same as T_1, except that webs were made up of three widths joined by longitudinal cover strips. The web of T_1 would require plates 95 ins. wide, which would probably cost more than new cover plates. The web of each rib in T_7 was made of two thicknesses as in T_1, but one plate was made up of two widths and the other of three widths.

Average cross-section, by weight, 55.249 sq. ins. for both T_7 A and T_7 B. Length-ratios the same as for T_1.

Constructional details: Diaphragms as for T_1. Pin bearing at one end, with bearing area 56% in excess of body; flat bearing face at other end, with 52% excess.

T_2.—Model (¼ linear) of bottom chord section at outer end of cantilever arm, L2—L4.

Dimensions: 16⅝ ins. deep at inner end, 15⅛ ins. at outer end; width, 24½ ins. c. to c. outer ribs, 22 ft. 6⅜ ins. long. Consists of four vertical ribs. Average cross-section, 40.84 sq. ins. by weight, for both T_2 A and T_2 B. Cross-section at point of failure, 40.21 sq. ins. Length-ratio, 43.6 around horizontal axis, 30.5 around vertical axis.

Constructional details: Similar to those of T_1, but T_2 lacks the radial angle reinforcement around the pin bearing. Inner end, flat bearing face with 110% excess over body; outer end, 8-in. pin, with bearing area 10% in excess over body.

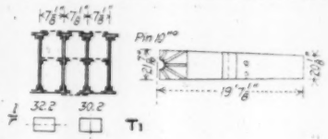
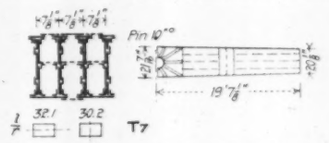
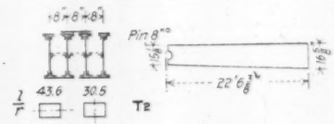
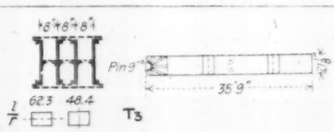
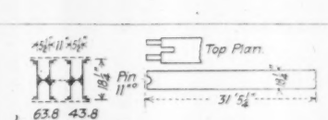
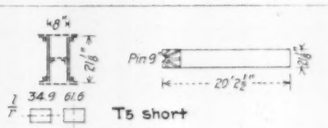
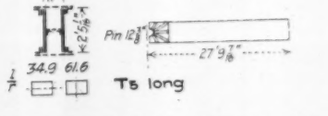
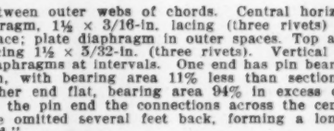
T_3.—Model (¼ linear) of main diagonal L14—M13 of the cantilever arm, extending upward from the main pier.

Dimensions: 21¼ ins. deep (uniform); about 22 ins. wide back to back of outer rib angles; 35 ft. 9 ins. long. Consists of four vertical ribs laced together in four planes. Cross-section, by weight, 56.958 sq. ins. for T_3 A, 57.10 sq. ins. for T_3 B. Length-ratio, 62.3 around horizontal axis, 48.4 around vertical axis.

Constructional details: Central horizontal diaphragm, 1½ × 3/16-in. bars (four rivets) in middle space, [illegible]

TABLE OF TEST RESULTS.

Tests of Model Columns of Nickel-Steel, made for Board of Engineers, Quebec Bridge.
Tests made May-July, 1910, in Machine of Phoenix Iron Co., Phoenixville, Pa.

Test Piece	Scale of Model.	Cross section, sq. ins.	Make-up † (dimensions in ins.)	Form and General Dimensions.	Elastic ‡ limit, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	
T1 A	1:4.5	55.806* Later reduced by drilled holes to 46.335	Webs 8 pl. $20^{21}/_{32} \times 7/_{32}$ Top flange 4 L 2 x 2 x 3/16 4 L 2 x $1^{5}/_{8} \times {}^{5}/_{32}$ 4 flats 2 x 1/8 4 cover pl. 4 x 1/4 1 cov. pl. $6^{5}/_{8} \times 1/8$		41,650	(50,100 not broken. Then two 2⅝-in. holes drilled in each web.) 59,900 §	Did not fail at max. load. Two 2⅝-in. holes bored in webs, reducing section to 46.335 sq. ins. On retesting, failed by local buckling of webs at holes. Two rivets in top lattice and one rivet in vert. leg of lower flange angle sheared.
T1 B		57.497* Later reduced by drilled holes to 48.722	Bottom flange 8 L 2 x 2 x 3/16 2 cov. pl. $11^{1}/_{2} \times 3/8$ Center diaphragm 6 L 2 x $1^{3}/_{8} \times {}^{5}/_{32}$		38,200	(48,700 not broken. Then two 3¾-in. holes drilled in each web.) 64,000 §	Did not fail at max. load. Two 2 13/16-in. holes bored in webs, but member again did not fail (60,000 lbs. per sq. in.). Holes enlarged to 3¾-in., reducing section to 43.722 sq. ins. On retesting, failed by local buckling of webs at holes (63,900 lbs. per sq. in.).
T7 A	1:4.5	55.249*	Like T1, except webs made up thus: Webs 8 pl. $59/_{64} \times 3/16$ 4 pl. $10^{1}/_{4} \times 3/16$ 8 pl. $10^{19}/_{64} \times 3/16$ 8 spl. pl 2 x 3/16		37,400	50,100	Failed by buckling of ribs at diaphragm nearest central splice. Many loose rivets in this vicinity and at pin end. One rivet head came off at low load.
T7 B		55.249*			35,000	48,800	Failed by buckling of ribs at diaphragm nearest pin end.
T2 A	¼	40.21 at breaking point.	Webs 4 pl. $15^{3}/_{4} \times {}^{9}/_{32}$ Top flange 4 L 2 x 2 x 3/16 4 L 2 x $1^{1}/_{2} \times {}^{5}/_{32}$ 4 flats 2 x 3/16 4 cov. pl. 4 x 5/32 1 cov. $7^{1}/_{8} \times 3/16$ Bottom flange 8 L 2 x 2 x 3/16 2 pls. 12 x 3/16 Central Diaphragm 6 L 2 x 1½ x 3/8		38,500	57,800	Failed by buckling of ribs at diaphragm nearest pin end.
T2 B		40.21 at breaking point.			41,700	58,300	Failed by buckling of one rib at diaphragm nearest pin end, and three ribs at next diaphragm.
T3 A	¼	56.958 Later reduced by drilled holes to 46.792	Webs 8 pl. 21 x ¼ Flanges 8 flats 2 x ¼ 8 L 2 x 2 x ¼ Central diaphragm 6 L 2 x 1½ x 5/16		36,300	(49,100 not broken. Then two 2 ½-in. holes drilled in webs.) 55,500 §	Did not fail at max. load, even with 7,000 lbs. load applied at center. Two 2½-in. holes bored through webs. On retesting, failed by local buckling of webs at holes.
T3 B		57.10 Later reduced by drilled holes to 44.871			38,500	(49,000 not broken. Then drilled two 3-in. holes in webs.) 58,300 §	Did not fail at max. load, even with 17,000 lbs. load applied at center. Two 3-in. holes bored through webs. On retesting, failed by buckling of webs at holes.
T4 A	¼	45.763	Webs 4 pl. 18 x $^{13}/_{32}$ Flanges 8 flats 2 x ¼ 8 L 2 x 2 x ¼ Central diaphragm 10 L 2 x 1½ x 5/16 2 pl. 4½ x 1/8		36,800	50,800	Failed by general deflection down, but deflection limited accidentally by blocking under the piece, giving higher ultimate (52,700 lbs. per sq. in.). Many rivets sheared. Angle at center of rib broken. Scaling on forked ends near pin.
T4 B		45.763			38,600	51,300	Failure as in T4A; inner webs bent out at top.
T5 Short A	¼	27.59	Web. 4 pl. 21 x ¼ Flanges 4 L 2 x 2 x ¼ 4 flats 2 x ¼ Central diaphragm 2 L 2 x 1½ x 5/16		40,700	55,000	Failed by buckling of ribs at a transverse diaphragm.
T5 Short B		27.59			42,000	57,000	Failed by buckling of ribs at diaphragm nearest pin. One lacing-bar torn; one angle of lower half of diaphragm torn from rib.
T5 Long A	1/11 of full size member, or 1⅝ times linear size of T5 Short	52.305	Web 4 pl. $28^{7}/_{8} \times {}^{11}/_{32}$ Flanges 4 L $2^{3}/_{4} \times 2^{3}/_{4} \times {}^{11}/_{32}$ 4 flats $2^{5}/_{8} \times {}^{11}/_{32}$ Central Diaphragm 2 L $2^{5}/_{8} \times 2^{1}/_{16} \times {}^{9}/_{16}$		30,800	51,100	Failed by buckling of ribs near a transverse diaphragm.
T5 Long B		52.305			30,800	51,900	Failure at diaphragm, as in T5 Long A.
T6 A T6 B	¼	Min. section 56.66 Max. section 114.70	.....		.....	.....	Max. load, 49,000 lbs. per sq. in., did not cause complete failure. Cover-plate bulged where longitudinal rivet-spacing was 10½ times thickness of plate, and upper flanges of outer ribs bulged out. (T6A; T6B similar.)

*Sections for tapered chords T1 and T7 are the average sections, except that the sections as reduced by drilled holes are the sections at the location of the holes.
†Rivets on basis of 1-in. rivets in webs, ⅞-in. rivets elsewhere; e. g., for 1:4 models, ¼-in. rivets in webs, 7/32-in. rivets elsewhere.
‡Compare the stress-strain curves, Fig. 8, for values of elastic limit. Values obtained by inspection of compressometer readings were generally higher than those given in table, in some cases by 7,000-8,000 lbs. per sq. in.
§Net section deducting the bored holes.

5/32-in. bars (four rivets) in outer spaces. Top and bottom lacing 1⅞ × 7/32-in. bars (five rivets) in outer spaces, tie-plates in middle space. Vertical transverse diaphragms at intervals. This member to be erected in two halves, left and right, the connection being made by a row of lattice in the central diaphragm and tie-plates in upper and lower flanges. The two halves to be seated on independent pins. Shop splices at two points in length. One end pin bearing, 9-in. pin, with bearing area 77% in excess over body. Other end flat bearing face, 135% in exccess. Pin end reinforced by radial stiffening angles.

T_4.—Model (¼ linear) of second compression diagonal outward from pier in cantilever arm.

Dimensions: Depth, 18¾ ins. (uniform); width, 22 ins. b. to b. outer flange angles; length, 31 ft. 54 ins. Four vertical ribs laced together in three planes. Cross-section 56.03 sq. ins. Length-ratio, 63.8 around horizontal axis, 43.8 around vertical axis.

Constructional details: The two outer webs on each side are closer together than in other members, to fit between outer webs of chords. Central horizontal diaphragm, 1½ × 3/16-in. lacing (three rivets) in middle space; plate diaphragm in outer spaces. Top and bottom lacing 1½ × 3/32-in. (three rivets). Vertical transverse diaphragms at intervals. One end has pin bearing, 11-in. pin, with bearing area 11% less than section of body. Other end flat, bearing area 94% in excess over body. At the pin end the connections across the central space are omitted several feet back, forming a long "forked end."

T_5.—Similar to (but shorter than) one longitudinal half of T_3, and intended to represent a half section of L14—M13, as this member would be required to carry erection load before the second half could be erected. Two ribs laced together in three planes.

T_5 Short.—Same scale (¼ linear) as T_3. Depth, 21⅛ ins., width, 8 ins. b. to b. flange angles; length, 20 ft. 2½ ins. Cross-section, 27.59 sq. ins. Length-ratio, 34.9 around horizontal axis, 61.6 around vertical axis. Proportions of bearing area at pin and flat ends as in T_3.

T_5 Long.—Longer scale (1:22 in place of 1:4 linear), so as to get as large a test-piece as the machine could rupture. Depth, 29 1/16 ins.; width 11 ins. b. to b. flange angles; length, 27 ft. 9 7/16 ins. Cross-section, 52.305 sq. ins. Length-ratios and proportions of end-bearing areas the same as for T_5 Short. Pin, 12⅜ ins. Lacing, top and bottom 2 19/32 × 5/16-in. (5 rivets); central diaphragm, 1¾ × 7/32-in. (4 rivets).

T_6.—Model (1:4 linear) of panel-point L6, cantilever arm bottom chord. The horizontal diaphragm being omitted at panel-points for a sufficient length to accommodate the connecting web-members, and the legs of the upper flange angles being cut away, the section is not as fully stiffened as the body of the chord. The reduction of section is made up by reinforcement, but the area of cross-section necessarily varies considerably, and local concentrations of stress may occur.

Dimensions: Depth, 17⅝ ins. to 18⅝ ins.; width, abt. 24 ins. c. to c. outer ribs; length, 7 ft. Cross-section, 56.66 sq. ins. minimum, 114.7 sq. ins. maximum. Length-ratio variable but small when referred to integral cross-section. Both ends flat, bearing areas, 84 and 85 sq. ins.

METHOD OF TESTING.—All members were tested in horizontal position. No attempt was made to counterbalance their weight. The bending stress due to the weight in no case exceeded 3% of the ultimate axial load, and in most cases was much less. The deflections and the compressometer readings indicated at best a very slight influence of weight; for example, in three tests the measured compression was greatest on the lower face and the deflection was upward.

With the exception of T6, the test members had pin bearing at one end and flat bearing at the other. The pin bearing was so detailed as to eliminate practically all bending in the pin. The flat end bore against the planed surface of a heavy casting, through which the pressure of the ram was applied. T6 had flat bearing at both ends.

Deflections were measured by steel scales and squares from fine wires stretched longitudinally over the top flange, one wire being used in the case of the two-rib members (T5), and two wires in the case of the four-rib members. Deflections were measured at from four to seven points in the length.

Compressive deformations were measured by four Johnson extensometers. The measuring length varied for the different members from 14 ft. to 20 ft., except that in the panel-point (T6) the length was 5 ft. The measuring rod for each extensometer consisted of 5/8-in. brass tubing, in lengths joined by screw couplings. One end of the rod was set-screwed in an eye attached to a bracket riveted to the test member, while the other end carried an oval wooden bearing-piece which rested on the indicator spindle of the dial; the spindle housing was bolted to a bracket riveted to the members as at the other end of the rod. The dial read to 0.001-in., and by vernier to 0.0001-in. The measuring rod was supported by cords at intervals.

The dials were set at zero under small initial loads, varying from 3,400 to 6,170 lbs. per sq. in. The stress-strain curves in Fig. 8 therefore lack the usual irregular lower section, and, of course, do not start at the zero-point.

A Shaw mercury gage served to measure the fluid pressure in the ram cylinder, and thus the loads. The ram area effective in compression tests is 3,227 sq. ins., so that the maximum capacity of the machine, 2,800,000 lbs., corresponds to 867 lbs. per sq. in. gage. Load was applied in increments of 100 lbs. gage up to a total gage-pressure of 500 lbs. per sq. in., increments of 40 up to 580, and increments of 20 for the remaining range of loading.

RESULTS.—The test results and some detail remarks are brought together in the Table of Test Results, on page 529. The Schedule of Test Members should be read in connection with this table.

Sketches of the rupture region for four representative cases of the sixteen are given in Fig. 9.

As will be seen from the remarks in the table of results, several of the members were too strong to be ruptured by the maximum pressure of the machine. They were taken out of the machine, two large holes drilled through all four webs and the piece re-tested; in one case even the re-test did not lead to rupture, and the holes had to be bored out to larger size.

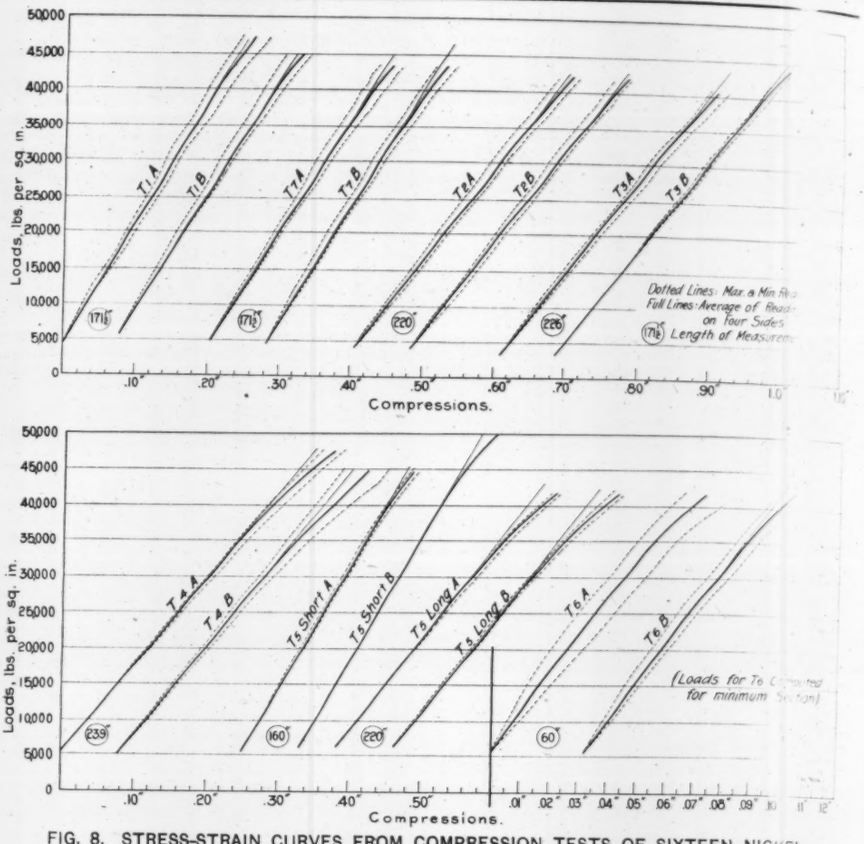


FIG. 8. STRESS-STRAIN CURVES FROM COMPRESSION TESTS OF SIXTEEN NICKEL-STEEL STRUTS OF LARGE SIZE.

(Tests of models of compression chords and web-members for new Quebec Bridge, design of Board of Engineers.)

In all cases of weakening by boring holes, ultimate failure occurred at the weakened section. Any tendency toward general body failure, i. e., buckling of the whole length or any large portion of the length of the column, would be masked by the artificial localization of failure. In fact only two of the 14 columns failed by integral deflection, 12 failing by local buckling or wrinkling. The two panel-point specimens T6 cannot be compared with the others.

It is also noted that in most of the cases where the point of rupture was not localized by holes bored in the webs, failure took place at a transverse diaphragm.

The table of results shows that the elastic limit of the columns ranged from 37,000 to 45,000 lbs. per sq. in. The ultimate strength ranged from 48,800 to 64,000 lbs. per sq. in. Those members which had holes bored in the webs to weaken them showed distinctly higher strengths (computed on the basis of reduced section) than the other members, which suggests that the conditions surrounding their failure were not normal column conditions. Omitting these members, the range of ultimate strengths is from 48,800 to 58,300 lbs. per sq. in.

Comparing these figures with the tensile test results of the material as previously given, it is seen that *the columns failed at loads slightly below the elastic limit of the tensile tests.* This conclusion is fully in agreement with the showing of previous tests of large and well-made columns.

The deformation observations supply information as to the behavior of the columns before failure. In Fig. 8 are grouped the stress-strain curves for the 16 test members. The limit of proportional deformation shown by these curves ranges from 35,000 to 40,000 lbs. per sq. in., with only two cases (T5 Long A & B) notably lower. The columns T5 Long may have had abnormal eccentricity; but if this accounts for the early departure from elastic action, their ultimate

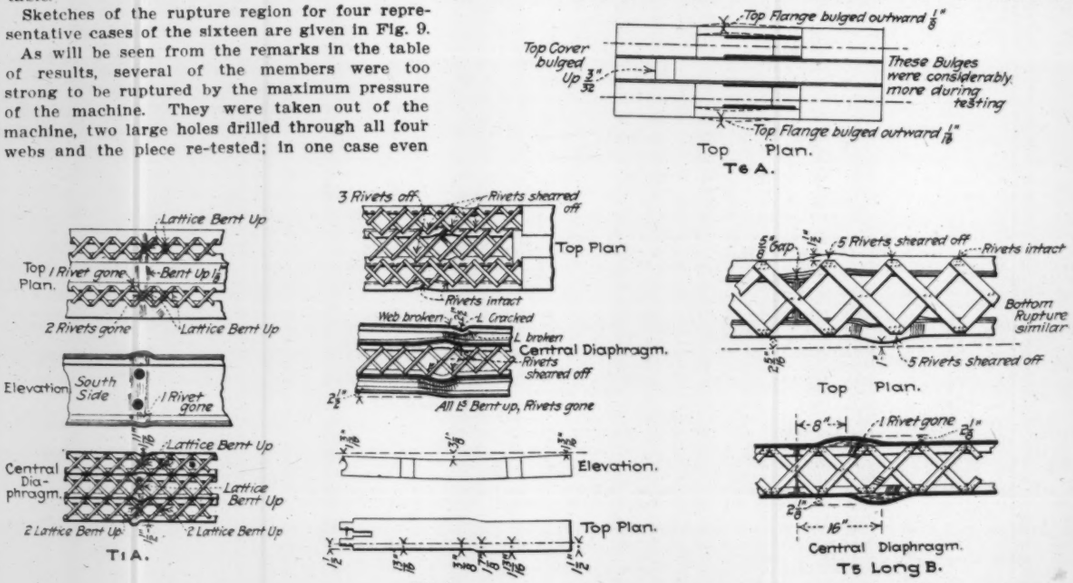


FIG. 9. SKETCHES OF FOUR TYPICAL FAILURES IN TESTS OF NICKEL-STEEL COLUMN MODELS.

strength on the other hand was not materially reduced. Since the table of test results shows the strength of Ts Long to compare well with the strength of several other columns in the series.

The mean range of elastic limit of the columns is, roughly, about two-thirds of the tensile "elastic limit" of small-size test-pieces, as tabulated above. This conclusion also agrees with the showing of previous column tests.

The tests were made under the supervision of Mr. Charles Scheidl, assisted by Mr. D. Gainor, of the Phoenix Bridge Co. Prof. H. M. Mackay, Professor of Civil Engineering at McGill University, Montreal, represented the Board of Engineers, Quebec Bridge.

The Development of Mechanical Traction on Roads in Great Britain.*

By L. A. LEGROS,† M. Inst. M. E.

Though attempts were made to adopt mechanical means as aids to locomotion on the common roads in England as early as 1830, and subsequently about 1860, these efforts were in both cases impeded, and ultimately checked, by the opposition of those interested in horse-drawn vehicles and contingent vested interests. A limited amount of haulage, it is true, was done by means of heavy traction engines, but this was only effected under conditions so onerous that their field of usefulness was extremely limited.

The first notable break from the traditions of animal traction, in which mechanical methods of progression were used on the road (though actually employing muscular effort) was that created by the advent of the bicycle and by its adoption, in the first instance for sporting and pleasure purposes, and later on as a rapid means of transport, for business and trade purposes.

In other European countries where the influence of those interested in traction by animals was not such a serious factor, attempts at mechanical locomotion on the road, and particularly on that of vehicles on which internal combustion engines were used, had been made with more than a fair measure of success. In fact, the results obtained abroad by the use of the internal combustion engine, both on street railways and on the ordinary roads, led up to the passing of the Light Locomotives Act of 1896. This practically freed the roads of Great Britain to mechanical traction. From this point, therefore, any real advance in road locomotion must be dated. The first four years of this period have been dealt with in the paper on "Road Locomotion," by Dr. H. S. Hele-Shaw, read before this Institution in 1900. It is the succeeding period with which the present paper deals.

The various forms of road locomotion may be classed as follows: (1) Cycles, including carrier cycles; (2) automobile vehicles used for pleasure purposes; (3) light automobile vehicles employed in public service (motor cabs); (4) heavy motor vehicles employed in public service (motor omnibuses); (5) light motor vehicles employed for commercial purposes (motor delivery vans); (6) heavy motor vehicles employed for carrying, and in some cases also for hauling (motor lorries with or without trailers); (7) light road locomotives; (8) heavy traction engines; (9) mechanically and electrically propelled street cars.

MOTOR CABS.—Following the application of the internal combustion engine to pleasure vehicles comes its application to public vehicles, such as cabs. Several attempts to introduce this kind of locomotion in London in the earlier days of the industry proved abortive owing to the heavy first cost of vehicles at that date, and to the excessive repairs, and largely to the want of experience on the part of the designer and the user of the vehicle. The total number of motor cabs licensed in 1909 was 3,956. The motor cab has proved so much more expeditious than the horse-drawn cab that the period at which these latter vehicles will become practically obsolete in large towns is obviously close at hand.

MOTOR OMNIBUSES.—The motor omnibus has not followed along the same lines of development as those taken by the motor cab. The frame of the motor omnibus is of necessity of much heavier construction than that of the motor cab on account of the greater weight it has to carry. The total weight is, in fact, so great as to prohibit the use of the pneumatic tire, and to necessitate the use of solid rubber together with such constructional modifications in the framing and mechanism as have been found necessary to meet the conditions arising from less efficient cushioning of the weight not carried by springs. The motor omnibus has, in fact, more closely followed the motor truck than the pleasure vehicle.

The total number of motor omnibuses licensed in London in 1909 was 1,180, and the average annual mileage was 10,000 miles. Both steam and gasoline engines are employed on the motor omnibuses in London. The number of steam omnibuses is, however, relatively small. One of the gasoline omnibuses was stated to have traveled 138,100 miles.*

Several railway companies have adopted the motor omnibus for service in places where their stations lie at some distance from the towns they serve, and in many cases they are employed where small outlying towns, otherwise devoid of regular communication, could not be economically connected to the railway service by other means. Particulars of the services and mileage run by these omnibuses on the regular services are given in the accompanying table. It is impossible to obtain exact data as to the total mileage run; the figures in the table do not take account of the mileage of duplicated omnibuses, nor do they show the long distances covered by the summer services, which on some railways (on the Northeastern Ry. in particular) are very great; nor is it possible to obtain data of costs of working. The author is of opinion that the average cost of working these omnibuses, including wages of driver and conductor, fuel and oil, cleaning and waste, maintenance and renewals (in fact, all running expenses, but not depreciation) will be found to be between 19 and 21 cts. per mile.

MOTOR OMNIBUSES OF BRITISH RAILWAYS.

Railway.	No. of omnibuses. Total.	Min. for service.	No. of routes.	Per annum. Single trips.	Total run, miles.	Total run per omnibus, miles.	Longest trip, miles.	Average single trip, miles.	Mean speed, m. p. h.
Gt. Western	96	50	34	114,842	825,458	16,510	20.6	7.19	9.24
Lon. & N. W.	13	11	10	85,488	252,861	22,990	11.4	2.96	9.19
Gt. No. Scot.	..	7	5	8,320	130,780	18,683	19.3	15.09	10.04
Northeastern	..	6	4	16,900	56,907	9,435	22.6	3.35	9.76
Gt. Eastern	..	6	5	14,144	86,736	14,456	10.9	6.13	9.72
Lon. & S. W.	..	4	2	3,172	45,687	11,422	21.4	14.40	8.87
Cambrian	..	2	1	2,080	16,224	8,112	7.8	7.80	5.57

Calculated from the published time-tables of the respective railways.

The life of the tires on motor omnibuses is generally guaranteed at 10,000 miles. The life of the omnibuses cannot at present be ascertained, but it appears that with proper maintenance and supervision they remain in good working order and have a considerable life after six or seven years' service. These data are necessarily based on omnibuses of early design; the improvements which have since been made in accessibility and interchangeability of parts lead to the conclusion that the life of the later types will be considerably increased.

The railway services in many instances rest on a much less favorable basis than those of the omnibus companies. The only railway motor omnibus service approaching a town service in respect to the continued employment of the vehicles is that of the London & Northwestern Ry. at Watford, in which the omnibuses seldom wait more than a few minutes at the end of a trip. In general these services are dependent on the arrival and departure of the railway trains to such an extent that long waits are involved, with corresponding reduction in the daily mileage of each omnibus. Some of the services, again, are run over extremely hilly and difficult country.

Systems of railless electric traction, in which the cars are supplied with power from a central station, have been developed on the Continent with such success that some municipal authorities in this country have obtained powers to enable them to use the method.

LIGHT MOTOR WAGONS.—The development of these vehicles has taken place rather more slowly than that of pleasure vehicles and motor omnibuses. The necessity for keeping down the weight of the vehicle has required the adoption of light construction resembling that of the pleasure car, while, at the same time, the addition of the load has raised the total weight above that at which the pneumatic tire can be economically employed. Hence a large amount of special experience was required to be obtained before the reliability of this type of vehicle could be assured.

One of the most important individual applications of this type of vehicle is that of the General Post Office, which has 126 vehicles. The number also of motor vans so employed is growing weekly. One large firm in London has 80 vans on the road, each averaging 60 miles per day, while another London firm has 55 wagons running from 70 to 100 miles per day.

The total number of trade vehicles coming under the Light Locomotives Act in the United Kingdom in September, 1909, is stated to have been 15,181. It is estimated that about 8,700 were light delivery vans and 6,500 were lorries of three tons and upwards, with which are included light traction engines.

HEAVY MOTOR TRUCKS.—Of the 6,500 light locomotives just quoted probably 5,000 are motor trucks. Many of these are driven by gasoline engines, but unlike the motor omnibuses the majority are fitted with steam engines. The slower speed of these vehicles and the greater permissible weight render the use of a fire-tube boiler possible. Of 42 of these vehicles entered for a recent driving competition two were stated to have run 85,000 miles and upwards, and 17 to have run 50,000 miles and upwards. With the lorries and heavier vehicles about 10,000 miles per annum appears to be the usual performance, while 25,000 miles per annum appears to be the maximum for the lighter commercial vehicles. Some of these vehicles belonging to carrying companies make trips of over 200 miles from their base. Among the various uses of motor lorries, apart from general carrying, may be noted their employment by borough councils for purposes connected with road maintenance, scavenging, cleaning and watering.

LIGHT TRACTION ENGINES.—The light traction engines built for licensing under the Light Locomotives Act are not so numerous; they find employment under a number of conditions where very bulky loads require to be hauled over comparatively easy country; a typical case is the haulage of vegetable produce to the London market.

HEAVY TRACTION ENGINES.—Whereas about 8,000 engines were in commission in 1896, it appears probable that their number has not increased by more than about 500 in the last 14 years. The reason is not far to seek; all lighter forms of work are undertaken by the previously mentioned classes of trade vehicles, and the heavy traction engine is no longer employed for such light jobs as it frequently performed in the earlier portion of the period under consideration.

The heavy traction engine has been responsible for the education of a body of drivers qualified to demonstrate the economical handling of the motor truck. As a class these men are most resourceful and highly intelligent. In the case of those who drive for fairs and circuses they are not only extremely skilful drivers, but require to have an all-round engineering knowledge for maintaining in working order the mechanical appliances, electric light plant, etc., entrusted to their charge.

In many parts of the country a great outcry has been raised against mechanical traction, and much has been said and written with the object of proving that the new method of traction has caused damage to the existing roads which were supposed to be excellent and adequate for horse traffic. An examination of most of these statements, however, will show the following: (1) the roads were constructed on an insufficient foundation; (2) the roads were made of unsuitable material; (3) the stone for the road was not broken to proper size; (4) in the rolling operations, road scrapings, together with other dust and mud-producing matter, were mixed with the road metal proper or spread on and watered in with the stone to act as "binding;" (5) the roads were constructed with an excessive amount of camber. Attention has been drawn to all those points, and in many cases a very great improvement in the condition of the roads has been effected by avoiding these obvious sources of trouble.

It has been stated that in the past five years the number of horses stabled in London has fallen from 500,000 to 110,000. The decrease in horse omnibuses, street cars and cabs is responsible for a very large reduction, because 10 to 12 horses (for relay) were necessary for each horse omnibus or street car, and many of the cabs were run by two horses each day. In the period 1903-8 about 2,300 horse cars and omnibuses were taken off, and during the same period about 2,700 two-wheel cabs. These together would account for 30,000 horses being taken off the road. If the trade vehicles are taken into consideration, probably 50,000 horses were taken off in this period for public service and trade purposes. Even allowing for the superseding of the private carriage by the motor car, the author is of opinion that the total reduction of horses in use in London has not greatly exceeded 100,000 in the past five years.

*Abstract of a paper read before the Institution of Mechanical Engineers, London, England.

†Watford, England.

*Some of the London motor omnibuses were described and illustrated in our issues of March 7 and 21, 1907.

THE ANTI-PLAGUE CAMPAIGN IN CALIFORNIA cost the U. S. Government $795,643 from July 1, 1907, to Jan. 31, 1911. In addition California state and local authorities have probably spent over $500,000 for the same object. During this period there were 159 cases with 77 deaths in San Francisco, 12 cases and 7 deaths in Oakland, and 9 cases elsewhere in California (deaths not given). No case of plague has been found in San Francisco since Jan. 30, 1908, nor elsewhere in California since Aug. 23, 1910. A large portion of the expense incurred in fighting the plague has been for catching rats and ground squirrels, of which no less than 992,247 were "collected" between September, 1907, and March 4, 1911. Of these 729,621 were "examined for possible infection," and 937 were "found infected" (324 rats, 412 squirrels "and 1 wood rat"). The figures given take no account of the earlier plague outbreak, from 1900 to Feb. 29, 1904. Those interested in further details of this work can find it in "Public Health Reports" for April 21, 1911, published by the U. S. Public Health and Marine-Hospital Service.

Operating Costs and Qualitative Results of Slow Sand and Mechanical Filters, Baltimore County, Md.

By S. T. POWELL.*

So much has been written as to the relative efficiency of slow sand and rapid filtration that the writer has some hesitancy about reciting the results obtained from these two types of filters operated daily by the Baltimore County Water & Electric Co. The results, though, are thought to be of particular interest, as they were not obtained from small experimental filters, but from a plant operated on a practical scale, with a capacity of about 2,000,000 gals. a day.†

The filters are situated at Avalon, Md., nine miles southeast of Baltimore, and furnish water to a dozen or more suburban places throughout the county. The results given are for a period of about thirty months, during which time both types of filters were operated daily, excepting time out of service for cleaning and repairs.

The first year of operation the raw water was taken from Rockburn Branch, a small spring-stream two miles in length. Owing to the topography of the country through which this stream flows, there were often sudden rises in turbidity,

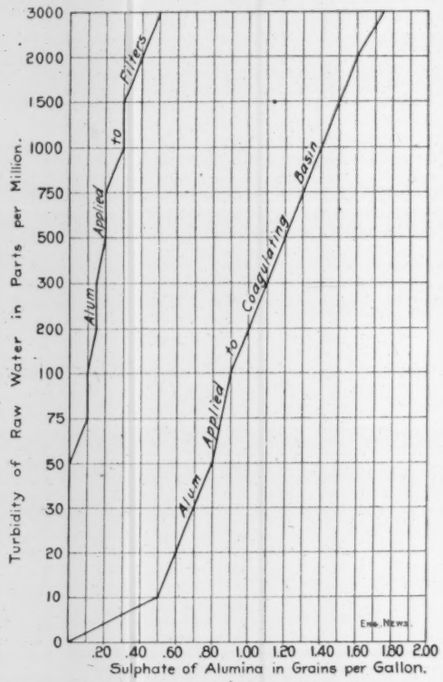

Turbidity of Raw Water in Parts per Million.
Sulphate of Alumina in Grains per Gallon.
Alum Applied to Filters
Alum Applied to Coagulating Basin
Eng. News

Fig. 1. Curve Followed in Determining Amount of Alum to be Used in Mechanical Filters, Baltimore County, Md.

due to surface washings from the steep hills surrounding.

During 1908, the turbidity varied from 5 to 5,000, with a mean of 194 parts per million. This supply, however, became inadequate, owing to an increase in pumpage, and during the past 18 months the raw water has, for the most part, been drawn from the Patapsco River. The water from both supplies is fairly soft, but there has always been enough alkalinity present to decompose the sulphate of alumina used. The organic matter is low, excepting at times of heavy rains, when a considerable amount is carried in suspension. The color varies greatly at different seasons of the year. At times the water is almost colorless, but during spring and fall floods, or whenever there are heavy showers, the water becomes highly colored. The color of the applied water during the test varied from 5 to 65 parts per million.

A special study was made of the color, particularly as to its removal by the slow sand beds. It was found that most of it was in true solution, although at times much of this organic stain was in a collodial condition. It is on this account that there is such a variance in the percentage of color removed by the sand beds.

The Patapsco River water is more contaminated than that from Rockburn Branch, but is not subject to as high turbidities. The reason for this is that the water is drawn from an impounding reservoir, and not from the stream proper,

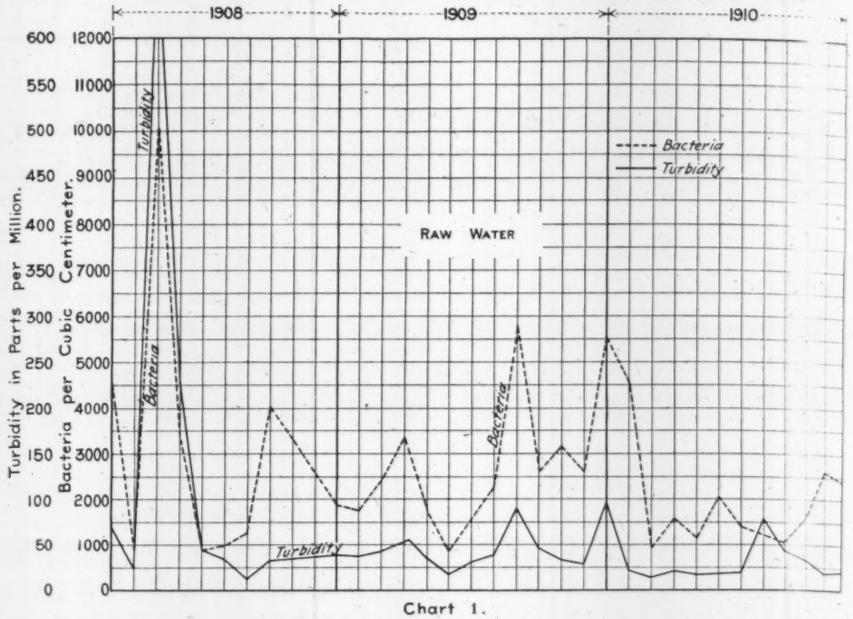


Chart 1.

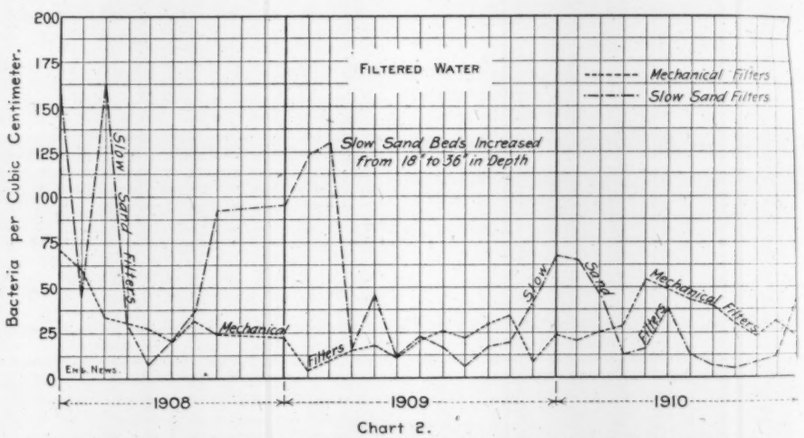


Chart 2.

FIG. 2. MONTHLY AVERAGES OF TURBIDITY AND BACTERIA IN RAW WATER AND OF BACTERIA IN EFFLUENTS FROM SLOW SAND AND MECHANICAL FILTERS IN 1908-10, BALTIMORE COUNTY WATER & ELECTRIC CO.

the water entering the reservoir by percolation through the earthen banks.

Slow Sand Filters.

The slow sand filters cover approximately half an acre, and are divided into two units, each unit, though, is operated independently, having its own controller and influent and effluent valves. The filter walls are of concrete, 48 ins. thick at the base, and 24 ins. at the top. The underdrains are of tile pipe, embedded in crushed stone. For the first twelve months of the test each sand bed was 18 ins. in depth. The mechanical analysis of this sand showed an effective size of .35 mm., with a uniformity coefficient of 2.22. The sand contained considerable loam and clay.

In April, 1909, all the sand in the first bed (No. 3) was removed and placed on the second bed (No. 4). Bed 3 was then filled to a depth of 36 ins. with a different grade of sand, having an effective size of .25 mm., and a uniformity coefficient of 2—a good grade of washed river sand which contained no loam or clay.

In making up the sand beds to 36 ins. they were also divided transversely by pine boards into sections 24 ins. wide. Instead of scraping the beds when dirty, they were from time to time cleaned by the Brooklyn method*. It may be said here that this method of cleaning the filters has up to the present time proven quite satisfactory both as to bacterial results and operating cost. Occasionally it is found necessary to spade up the sand to a depth of 1 ft., but this is never done until the bed has been thoroughly cleaned.

The rate of filtration has been maintained as near as possible at 2,000,000 gals. per acre per day. The filters are uncovered and are operated during the whole year.

Mechanical Filters.

The mechanical filters were constructed by the Pittsburg Filter Co. and were put into operation in the spring of 1908, from which time this test dates. There are two units, each having 370 sq. ft. of filter area. The rate of filtration is about 125,000,000 gals. per acre per day. Each unit is equipped with a loss-of-head gage, and rate controller usually seen on this type of filter. The sand beds are 34 ins. in depth, and are supported on 8 ins. of gravel. The effective size of the sand is .57 mm., and the uniformity coefficient 1.58. There are 200 strainers spaced 6 ins. c. to c. The beds when dirty are agitated by compressed air at 3.5 lbs. pressure, and the wash water is under 20 lbs. pressure.

The raw water is supplied by a centrifugal pump, direct-connected to a 19-HP. Wagner mo-

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†See Eng. News, for article entitled "The Pipe Line and Purification Works and Experiments of the Baltimore County Water & Electric Co.," by A. E. Walden, Eng. News, March 18, 1909.

*See Engineering News, Aug. 23, 1906.

tor. The water passes first through a settling basin holding four hours' supply, and from there to the filters. The alum solution is applied as the water enters the basin, so has four hours for coagulation and sedimentation. A 2% solution of aluminum sulphate is used, and the dose is regulated as the turbidity of the raw water fluctuates. The amount of alum necessary to remove the turbidity has in all cases been sufficient to remove

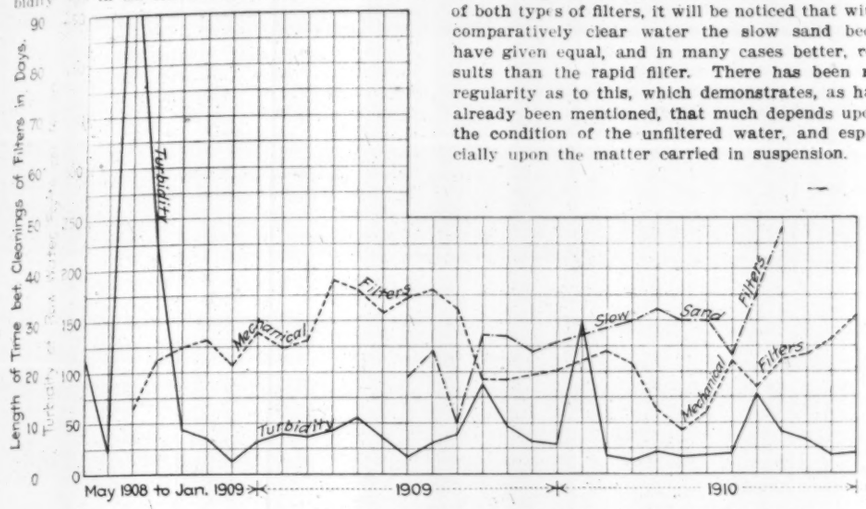


FIG. 3. RELATION BETWEEN FILTER RUNS AND TURBIDITY OF RAW WATER, BALTIMORE COUNTY WATER & ELECTRIC CO.

the color, and at the same time produce satisfactory bacterial efficiencies.

There is a sample pump operated by a 2-HP. motor, which delivers in the filter-house, samples of raw, treated and filtered water from both systems.

The curve followed in applying the coagulant is shown by Fig. 1, and needs no explanation other than is given on the diagram.

The results of the test are comparable, as the samples of the raw water, and both types of filters, were taken and analyzed at the same time.

Comparative results of the two systems, Fig. 2, show the bacterial results from the slow sand and rapid filters in comparison with the number of bacteria per cubic centimeter, and the turbidity in parts per million in the applied water. The most noticeable feature of the diagrams is the effect the depth of sand bed had upon the bacterial efficiencies of the slow sand filters. It is readily seen that with a sand bed of an 18-in. depth, the number of bacteria in the effluent was generally high, and, with but two exceptions, much greater than the number passing the mechanical filters. At the same time, the filtered water often contained a considerable amount of turbidity and color, depending on the amount present in the applied water. Although it is conceded that it is upon the "schmutzdecke" on the surface of the sand, and not the sand itself, that the efficiency of a filter depends, still the lower diagram in Fig. 2 shows clearly how unsatisfactory it has been to have a bed as shallow as 18 ins. As soon as the filter beds were increased in depth, there was a decided improvement in the efficiencies, which was noticeable immediately after the sand was in place. Comparing the diagrams comprising Fig. 2 it is seen that the results from the mechanical filters have been more uniform than from the slow sand beds, especially when the amount of suspended matter in the raw water has been great, and whenever it has been in a very fine state.

The general tendency of the bacterial line of the slow sand filters follows closely the turbidity curve of the raw water, but at times there are rises in the turbidity lines which are not followed by the bacterial curve. A careful study of the analytical data and conditions has shown that the efficiencies of these filters have been due more to the character of the turbidity than to the amount present. This condition was noticed particularly when the filter was first put in service after cleaning. That is, when the turbidity in the raw water was coarse, the efficiency of the slow sand beds was generally better than when in a finer state of suspension. The same conditions have not been noticed on the mechanical filters, as the alum used has coagulated the fine material, and by the time the water ran upon the filters it was in a condition to form a good mat upon the sand bed, and thereby give good bacterial efficiencies.

Following the bacterial curves from the effluent of both types of filters, it will be noticed that with comparatively clear water the slow sand beds have given equal, and in many cases better, results than the rapid filter. There has been no regularity as to this, which demonstrates, as has already been mentioned, that much depends upon the condition of the unfiltered water, and especially upon the matter carried in suspension.

A careful record has been kept of the length of time between cleaning the filters, and the results are shown diagrammatically by Fig. 3, in comparison with the turbidity of the raw water. The shortest length of time between cleaning the filters has not always coincided with the greatest amount of turbidity in the applied water, but has depended on whether the turbidity was coarse or fine, or of an organic or inorganic nature. In this respect both systems have been about the same.

The amount of dissolved oxygen in the raw and filtered water was determined at regular intervals during a period of about four months. These determinations were made to learn if in any way the amount of oxygen dissolved in the filtered water had any direct bearing upon the efficiency of the slow sand beds, and also if there was any direct ratio between the loss of oxygen in passing through the beds and the length of time the filters were in service. The results were platted separately for Filters 3 and 4 (Fig. 4), but were not reported for the mechanical filters, as there was no change in oxygen in passing through these filters. It will be noticed that the filtered-water curves in both series follow closely the curve from the raw-water tests. The amount of oxygen present in the filtered water was always less than in the applied water, and decreased as the length of time between cleaning increased. As soon as the beds were cleaned, there was immediately an increase in the amount of oxygen in the filtered water. This condition is noted on Fig. 4 by a "C" at the point in the curve where the beds were cleaned.

Whenever a bed was disturbed, and the "schmutzdecke" on the surface of the sand was broken (marked "B" on Fig. 4), the amount of oxygen in the filtered water was increased to about the same degree as when the bed was cleaned. This was noticeable even when there was no increase in the number of bacteria in the effluent. A noticeable feature of these oxygen tests is that the greatest loss while passing through the filters was during the shortest time the filters were in service between cleanings, occurring on both Filters 3 and 4. The sand in Filter 4 has, as mentioned above, an effective size of .35 mm., and a uniformity of 2.22, while in the sand in No. 3 unit has effective size of .25 mm. and a uniformity coefficient of 2.00. It is believed, though, that the greater loss of oxygen from No. 4 over No. 3 unit is due to the fact that the bed in the former has been in place a greater length of time, and is therefore more compact.

From a chemical standpoint, both types of filters have shown practically the same degree of purification, as shown by Table I. (p. 534), which gives the average of all samples during 1909-1910. The slow sand beds have not been able to entirely remove the turbidity and color, but have shown a slight increase in nitrates, with a corresponding reduction in nitrites. The effluent from the mechanical filters has, on the other hand, shown an increase in carbon dioxide and hardness and a decrease in alkalinity and required oxygen. These differences, though, are so slight as to be negligible.

Operating Costs.

The cost per million gallons of filtering the water by each system is shown in Table II. (p. 524). The cost has been classified under four main items: interest on investment, depreciation, operation and maintenance, and operating management.

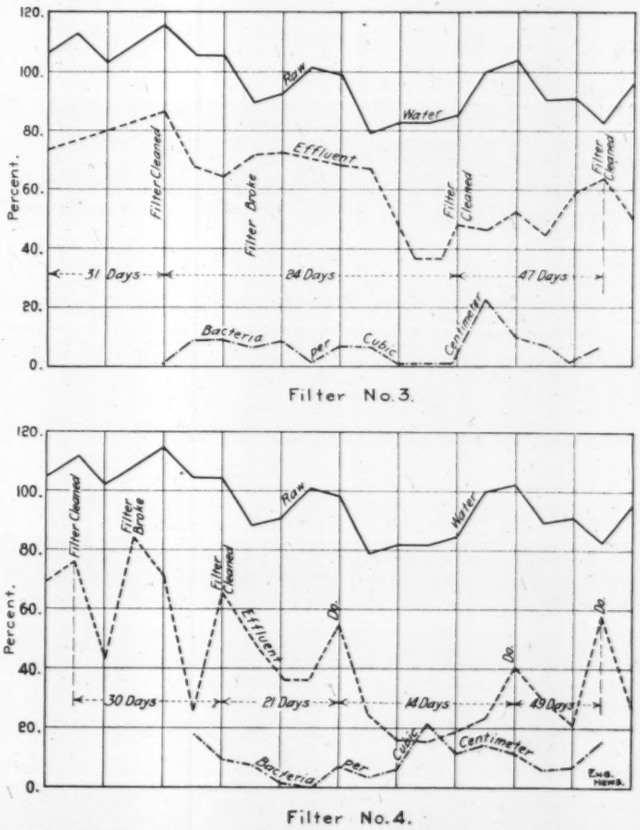


FIG. 4. PERCENTAGES OF DISSOLVED OXYGEN IN RAW WATER AND OF DISSOLVED OXYGEN AND BACTERIA IN EFFLUENT FROM SLOW SAND FILTERS NOS. 3 AND 4, BALTIMORE COUNTY FILTER PLANT, FOR FILTER RUNS OF VARIOUS LENGTHS.

TABLE I.—COMPARATIVE CHEMICAL RESULTS GIVEN BY MECHANICAL AND SLOW SAND FILTERS, BALTIMORE COUNTY WATER & ELECTRIC CO.

Constituents.	(Parts per Million.) Mechanical.	Slow Sand.
Color	0.0	3.8
Odor	None.	None.
Alkalinity	17.1	23.0
Turbidity	0.0	1.1
Total solid	62.0	60.0
Volatile matter	15.0	16.0
Ignited residue	47.0	44.0
Chlorine	4.1	4.1
Nitrates	0.378	0.386
Nitrites	0.0007	0.0003
Required oxygen	0.65	0.70
Iron	0.31	0.30
Carbon dioxide	4.0	3.0
Hardness	33.52	31.44

The interest on investment has been figured at 6% annually on the total construction cost and land valves.

Depreciation of the filters and coagulating basin has been calculated at 2%; controllers, solution tanks and orifice boxes at 5%; laboratory building and clear well at 1%; and 7% on the laboratory apparaus, which also includes all breakage.

The operation and maintenance item differs greatly for the two systems, as the slow sand filters are not covered, the water flows to the beds by gravity, and the cleaning is done by the Brooklyn method. Under this head comes the cost of chemicals, heating and lighting of filter house (mechanical plant only), electric current for blower, supply pump, sample pump, air compressor, and cost of wash water. This item also includes the operator's time for cleaning and other services, the chief engineer's time, and any extra labor required.

Under operating management has been placed the resident and consulting chemist's time, and all costs of chemical and bacteriological analyses, and whatever experimental work that was necessary.

It will be noticed that the maintenance and operating management charges are somewhat greater than at other places. This is due to the fact that the company employs a resident and consulting chemist, and has a laboratory completely equipped for chemical and bacteriological work, all of which could serve a plant of much greater capacity, which would thereby greatly lessen the cost per million gallons.

Conclusion.

From the results of the test, it will be seen that the mechanical filters have given more uniform results, and the average efficiency has been somewhat better, than from the slow sand beds. Eliminating the results of the slow sand beds for the first year, during which time the sand was only 18 ins. in depth, the mechanical filters still have shown somewhat better results, as appears from the following summary of bacterial results per cc. of water:

	Raw water.	Mechanical.	Slow sand.	Slow sand, omitting 1908.
	2,620	28	45	34
Efficiency	=	98.94%	98.29%	98.75%

The mechanical filters during the whole test have given good bacterial reductions, and have at all times entirely removed the color and turbidity of the raw water. The effluent of the slow sand filters, on the other hand, has been more difficult to control, and the results have fluctuated according as the condition in the raw water changed. These beds have also at times failed to entirely remove color and turbidity, especially if the matter in suspension was excessive, or if the color was much greater than 20 parts per million.

With comparatively clear water, low in color, the slow sand beds gave ideal results, as is shown diagrammatically in chart No. 2. The effluent from these beds, from July to December, 1910, contained on an average but 7 bacteria per c.c., while the average from the mechanical filters during the same period was 28 per c.c.

The cost of filtration has been somewhat higher for mechanical filtration, and although the figures cannot be considered the same for all localities, still it is believed that the comparative rates will be found to be about constant, provided, of course, that both plants are operated under identical conditions.

TABLE II.—RELATIVE COST OF SLOW SAND AND MECHANICAL FILTRATION, BALTIMORE COUNTY WATER & ELECTRIC CO.

Grand Summary.	Cost per million gallons of water filtered. Mechanical.	Slow sand.
Interest on investment	$3.16	$4.21
Depreciation	.38	1.41
Operation and maintenance	3.77	1.53
Operating management	1.21	1.21
Total	$9.12	$8.36

TABLE III.—ITEMIZED COST.

Interest on Investment:		
Filters and laboratory	$2.16	$3.61
Coagulating basin	.48	....
Controllers and tanks	.08	.16
Clear well	.44	.44
Depreciation:		
Filters and laboratory	.70	1.20
Coagulating basin	.16	....
Controllers and tanks	.04	.13
Clear well	.08	.08
Operation and Maintenance:		
Labor exclusive of chemist	.29	.17
Chemicals	1.94	.01
Electricity for supply pump	.96	....
Electricity for sample pump	.18	.18
Electricity for blower	.01	....
Electricity for lighting	.10	....
Heating	.13	....
Cleaning, washwater and removal of ice	.16	1.17
Operating Management:		
Chemists' salary	.82	.82
Laboratory expenses	.39	.39
Total	$9.12	$8.36

With results as obtained from the slow sand plant during the latter part of 1910, as mentioned above, the question naturally arises as to whether this character of filtration is better when the unfiltered water contains but a slight amount of color and suspended matter. Under these conditions, and with economical construction and operation, such filters would undoubtedly be preferred, especially when the cost of filtering the water is taken into consideration. Few surface waters, though, are to be found that are low in color and turbidity during the whole year, so that to obtain this condition will require sedimentation, and possibly coagulation. At the same time, the results could not be as readily controlled as by mechanical filters. If a settling basin and coagulation are necessary, the construction, as well as the operating cost, will naturally increase, so that the process may equal or exceed that of mechanical filtration.

The Spontaneous Combustion of Coal.

An investigation into the spontaneous combustion of coal is reported by Prof. S. W. Parr, and Mr. F. W. Kressman, of the University of Illinois, in the "Journal of Industrial and Engineering Chemistry" published by the American Chemical Society, issue of March, 1911. These studies are a continuation of other and preliminary studies which have been made at the University of Illinois and reported in various bulletins. To examine the causes underlying spontaneous combustion of coal, a study was made of the various forms of oxidation to which this material is subject and of the conditions which permit and promote such action. In the studies made into the weathering of coal, a marked drop in calorific value was found to occur in the first few days of breaking out from the mine. In Bulletin 38 of the Illinois Engineering Experiment Station, a partial explanation was given for this drop by the loss of hydro carbons, especially of methane (CH_4). In Bulletin 32, on "The Occluded Gases of Coal," confirmation was found of the fact that freshly-mined coal rapidly absorbs oxygen and in a way which does not result in formation of carbon dioxide (CO_2), but by the oxidation of certain unsaturated carbon compounds. In Bulletin 24 of the Experiment Station, entitled "Modification of Illinois Coal by Low-Temperature Distillation," data was obtained on the oxidation of coal at temperatures above 120°. These showed that the first appearance of CO_2 in all cases was at a temperature slightly above 120° C. This sort of oxidation did not reach a point where the heat generated was sufficient to raise the temperature of the coal above the temperature of the surrounding air until 140° to 160° was reached. At these temperatures the appearance of CO_2 was more evident, and the rise in temperature of the coal carried the thermometer readings above those for the surrounding air. With Pittsburg coal this point of rapid rise began at 175° and quickly reached the point of combustion as marked by the appearance of fire. With an anthracite coal the rapid rise point was found to be 240° C.

The experiments noted in the latest investigation were undertaken to determine not only the fundamental causes of oxidation, but also the importance of certain points involved, such as the influence of (1) iron pyrites, (2) size of particles of coal, (3) temperature, and (4) moisture content.

Four special ovens were constructed that several samples of the coal could be kept in an atmosphere maintained at a fixed temperature. Thermometers were inserted in the air space and in the coal mass. The coal was contained in a stone jar with a perforated bottom and open top. One corner of the oven was partitioned off to form a chimney for heating and circulating the air. Incandescent lamps were put in the chimney. It was found necessary in the first experiments to introduce a method of changing the air to secure uniform conditions as to the supply of oxygen.

The first size of coal used resulted from pulverizing to pass through an 80-mesh sieve. The second division included all material passing through ⅛-in. holes of a revolving screen, and a third division was made up of coal passing over the ⅛-in. and through the ¼-in. holes. Still coarser sizes were used in preliminary experiments, but the results were not essentially different from those with the coarsest particles here noted.

It was found by these tests that oxidation, especially in the more moderate degrees, was greatly accelerated by an increase in temperature. The fineness of the coal, on account of presenting a larger surface for contact with oxygen than the more solid masses, was found favorable for rapid oxidation upon reaching a suitable temperature. The fineness of division facilitated the initial oxidation of unsaturated compounds which have a marked avidity for oxygen, the products being humic acid and other products differing from carbon dioxide (CO_2). Coals were found to vary widely in this action, but it was largely dependent on the freshness of the coal and the fineness of division. This was termed the primary stage of oxidation.

The presence of sulphur in the form of iron pyrites was found to add heat, due to the reaction between sulphur and oxygen. This was termed the second stage in the process of oxidation, and here rapidity of reaction was found directly dependent on fineness of division. As a direct conclusion of the test, it is stated that, as the coals of the midcontinental field have a high content of sulphur in the fine material, the presence of dust is a positive source of danger of spontaneous combustion. Moisture also facilitated the oxidation of the pyrites.

The third state of oxidation existed by reason of the property of certain hydro-carbon compounds in the coal to oxidize to CO_2 and H_2O at temperatures above 120° to 140°. This form of oxidation was brought about when the contributory processes resulted in raising the temperature some 100° above the ordinary temperature and released sufficient heat to carry the oxidation to a fourth stage at temperatures of from 200° to 275°. This last stage is different from the others in that the action is not dependent upon a continual supply of external heat to keep up the reacting temperature. At about 300° the decomposition of the coal begins to give off heat more rapidly, and at 300° to 400° the ignition temperature is reached.

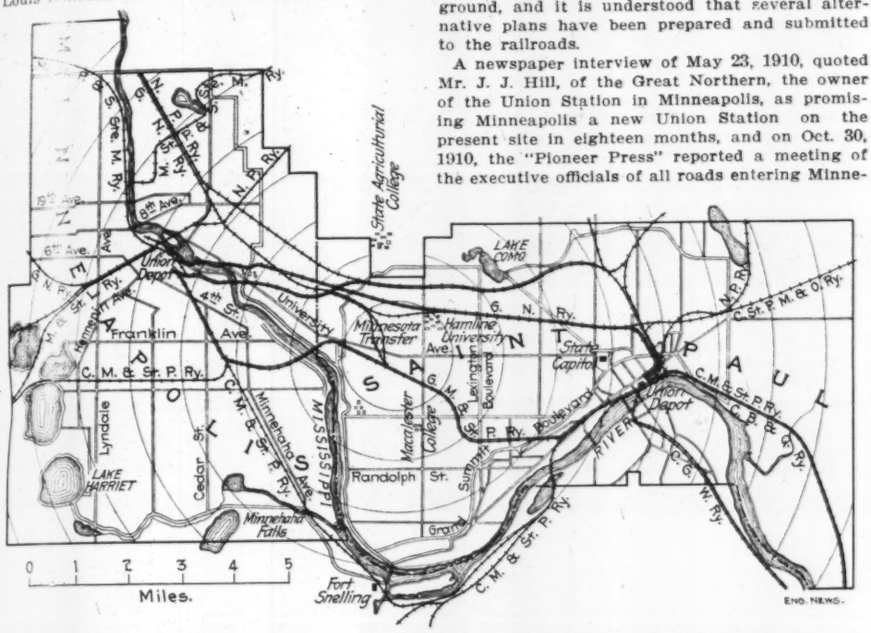
The following precautionary measures were suggested to prevent spontaneous combustion:

(1) Avoidance of external sources of heat; (2) elimination of dust; (3) dry storage; (4) artificial treatment with chemicals; (5) preliminary heating to effect the initial stages of oxidation; and (6) submerging the coal in water.

The St. Paul and Minneapolis Union Depot Problem.

By GEO. H. HERROLD,* M. W. Soc. Eng.

St. Paul and Minneapolis are each advocating the erection of a new union passenger station. The present Union Station at St. Paul is operated by the St. Paul Union Depot Co., stock of which is owned by the railroads using it. It is the only station in St. Paul and is located in the heart of the wholesale district. The Union Depot or Bridge Square Station, in Minneapolis, is owned by the Great Northern Railroad and is used by five other railroads as tenants. The Chicago, Milwaukee & St. Paul Railroad has a separate passenger station with the Minneapolis, St. Paul & Sault Ste. Marie and the Chicago, Rock Island & Pacific as tenants, and the Minneapolis & St. Louis Railroad enter their own station. The first and last-named are in the heart of the business district.



MAP SHOWING RAILWAYS AND STATION IN ST. PAUL AND MINNEAPOLIS.

The railroads entering these two cities are the Great Northern, Northern Pacific, Chicago, Milwaukee & St. Paul, Chicago Great Western, Chicago & Northwestern, Chicago, St. Paul, Minneapolis & Omaha, Minneapolis, St. Paul & Sault Ste. Marie, Minneapolis & St. Louis, Chicago, Burlington & Quincy and the Chicago, Rock Island & Pacific. The Great Northern, Northern Pacific and Chicago, Milwaukee & St. Paul, each have several lines into each city.

There are two double-track passenger lines between the Union Station in St. Paul and the Union Station in Minneapolis, owned by the Great Northern and Northern Pacific, respectively, and one double-track passenger line between the Union Station in St. Paul and the Chicago, Milwaukee & St. Paul Station in Minneapolis, owned by the Chicago, Milwaukee & St. Paul Railroad. These lines are used by all the other railroads in running through the two cities. The railroads from the East, Southeast and Northeast enter the St. Paul Union Station and pass over these tracks to the Minneapolis depots, and railroads from the West, Southwest and Northwest enter the depots in Minneapolis and pass over these tracks to the St. Paul Union Station.

There are 92 through trains daily, 46 trains originating and 46 trains terminating at the St. Paul Union Station, and 44 through trains daily, 30 trains originating and 30 trains terminating, at the Minneapolis Union Station.*

There are probably 30,000 passengers handled in and out of the depots in each city daily. The "Pioneer Press," speaking on the Union Depot question for St. Paul, states that in October, 1910, 5,860 passenger trains or 28,285 passenger cars were handled in and out of the Union Depot that month.

In 1909 the Mayor of St. Paul appointed the Municipal River, Depot & Harbor Commission to work up plans for a new Union Station, in conjunction with the railroads.

In June, 1910, this commission reported little progress on account of the various railroad interests not being in harmony as to the plans to be carried out.

According to newspaper reports in November, 1910, the railroads, acting jointly, through the St. Paul Union Depot Co., appointed a consulting engineer to draw plans and estimates of the proposed improvements, based on changing the channel of the Mississippi River and filling in the present channel in order to get the needed ground, and it is understood that several alternative plans have been prepared and submitted to the railroads.

A newspaper interview of May 23, 1910, quoted Mr. J. J. Hill, of the Great Northern, the owner of the Union Station in Minneapolis, as promising Minneapolis a new Union Station on the present site in eighteen months, and on Oct. 30, 1910, the "Pioneer Press" reported a meeting of the executive officials of all roads entering Minneapolis and the approval of the plans for the expenditures of $3,650,000 for a new Union Station.

March 31, 1910, the Union Depot Bill, a Minneapolis measure, was passed by the State Legislature and is now waiting the Governor's signature. It permits the organization of a Union Depot corporation in cities of 50,000 or more, with power to condemn land for a depot site, construct the depot and to compel all railways entering the city to use the depot.

St. Paul and Minneapolis are in reality "Twin Cities," as they are commonly known, divided only by political lines. Along the principal travelled thoroughfares between the two cities are well-built-up suburbs. The Mississippi River runs through both cities, but forms the boundary line between them for only a short distance. Means of transportation are provided by the Twin City Electric lines, with three double-track interurban lines and universal transfers in each city.

The history and growth of these two municipalities is not within the scope of this article, but a steamboat landing at the head of navigation on the Mississippi River was the beginning of St. Paul's great wholesale and shipping interests and a flour mill on St. Anthony Falls, Mississippi River, the nucleus around which Minneapolis's mammoth milling interests have been built up.

By the recent U. S. Census St. Paul has a population of 214,744 and ranks as the 24th city of the United States. Minneapolis has a population of 301,408 and ranks as the 17th city. The population of this double city is therefore 516,152, and if combined in one greater municipality it would rank as the 9th city of the United States and would take its place in the line of American cities, ahead of Detroit and Buffalo and next to Pittsburg. It would be the largest city west of Chicago. The increase in population of these two cities in the last ten years was 150,369.

The accompanying map shows the relation of these cities to each other. The mile circles are drawn with a center taken as a point midway between the business portions of the two cities on University Ave., which is the main thoroughfare between the two cities.

If any of the readers of this article desire to compare the area and shape of these two cities with that of other American cities, I would refer them to the issue of the Engineering News of Feb. 16, 1911, in which may be found portions of a report by Bion J. Arnold on "City Transportation Problems," in which is a series of cuts showing the size and shape of the larger American cities (not including St. Paul and Minneapolis) with mile circles drawn in reference to the center of their business districts.

Admitting for the moment that a Union Station should be maintained in each of the Twin Cities, only ten miles apart, then the important question is that of location; whether to build on the present sites or whether to select new locations in less congested districts, where ample ground could be secured for the necessary enlargement of present facilities.

From an article by F. A. Delano, president of the Wabash Railroad, Chicago, on "Railway Passenger and Freight Terminals" in large cities, published in the Engineering News of Jan. 5, 1911, I quote the following:

> In cities of less than 100,000 inhabitants it is desirable that trains shall deposit their passengers close to the business center of the city. But in larger cities this is no longer possible and to my mind it is highly undesirable. The reason for the conclusion is that the railroad terminals of a large city, if it is to be adequate to the needs, takes up directly and indirectly an immense amount of space, requires the closing of streets, and this interferes with the development and growth of a city.

It is this principle that I wish to direct attention to in considering the separate Union Depot plan in St. Paul and Minneapolis, for up to the present time an effort has been directed toward enlarging the present facilities in already congested districts. In fact, St. Paul should have had its lesson in the subject, for in 1901 and 1902 extensive enlargements were made to its present Union Station by doubling the size of its train shed and adding several additional tracks, the ground being secured by narrowing the river channel and at great expense. These enlarged facilities were practically inadequate at the time of their completion.

Taking into consideration the relative location of these two cities, their unity of business relations, the simplicity of the railroad trackage connecting them and the possibilities of selecting ample sites in either city for the construction of union depots, removed from their present congested locations, it would appear that a location should be selected for one union station to serve both communities.

The purpose of a union station is to facilitate the transfer of passengers, baggage, mail and express at gateways of traffic and unify the passenger business of a community.

To construct two union stations at this Northwest Gateway, within ten miles of each other, costing approximately $4,000,000 each, would be an economic error. It would also tend, in no small measure, to continue the individuality of these two cities, which is not to be desired, and it would not afford the traveling public the simplicity of service which one union station with individual borough and suburban stations would afford.

A NEW HIGHWAY LAW IN KANSAS, classifies the roads, and places the main highways connecting county seats and market centers under control of the counties, leaving the local roads only to the care of the towns. County roads are to be under charge of the county engineer who is to be paid $4 per day for time spent; but his total compensation per annum must not exceed the following:

In Counties having a population of—	Per annum.
Less than 5,000, the sum of	$400
More than 5,000 and not more than 10,000	500
More than 10,000 and not more than 15,000	600
More than 15,000 and not more than 20,000	700
More than 20,000 and not more than 25,000	800
More than 25,000 and not more than 30,000	1,000
More than 30,000	1,200

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*2351 Langford Ave., St. Paul, Minn.

†Committee Report on Yards and Terminals, 1910 Proceedings, Vol. 2, Am. Ry. Eng. and Maint. of Way Assoc.

Variability of Run-off of Minnesota Streams During the Low-Water Season of 1910.*

By ROBERT FOLLANSBEE,† Assoc. M. Am. Soc. C. E.

The few long-time stream-gaging records available for Minnesota rivers show that the flow during 1910 was less than that for any previous year, approaching, if not surpassing, the phenominally low water of 1864, which occurred prior to any records, but which is used locally as the standard of comparison. Therefore an account of the amount and variability of this run-off throughout the state will be of interest to engineers and others interested in Minnesota water resources.

During 1910, records of daily flow were compiled at 39 stations by the U. S. Geological Survey in cooperation with the State Drainage Commission. These stations were nearly all of the standard current-meter type, at which gage-height observations were taken twice a day or oftener. Sufficient discharge measurements were made to complete the rating curves applicable to the gage heights. In addition to the above-mentioned stations, a record of the flow of the Mississippi River above Sandy Lake Reservoir was maintained by the U. S. Engineer Corps.

The extreme variability of the run-off of the different streams is shown by the fact that although they were all at very low stage during the summer months, some of them continued at practically that stage for the remainder of the year, others rose considerably and had their flow increased during the rest of the year, still others rose during the fall, but fell again during December to a stage even lower than that reached previously, while a fourth class continued to fall slowly throughout the autumn months. About one-half the gaging stations considered were on streams that had their minimum flow during the summer months, while the remaining stations were divided among the other three classes. In the majority of cases where the minimum flow occurred later than the summer and early fall, the decrease was not great. (The exceptions to this statement are noted in the various river-basin descriptions.)

In order to have a common basis for comparing the run-off of the various streams during low water, and to show the rainfall for the portion of 1910 previous to that time, the mean flow for that month was taken which was the lowest for the greatest number of streams. An inspection of the records showed that during the period from July to September occurred the minimum flow which fulfilled these conditions, and in that period the majority of rivers had the low flow during August with very little difference in flow during the other two months. Accordingly, the lowest monthly mean during that period was chosen. Table I. has been compiled in the manner just described. It shows the drainage area above each station, the mean monthly flow in second-feet, the run-off in second-feet per square mile of drainage area above the point of measurement, and the lowest mean daily flow. The arrangement of the stations in the Mississippi drainage basin, which comprises the greater part of the state, is down-stream, beginning with the principal river, then following the same order on the tributary streams.

The Hudson Bay (Red and Rainy rivers) and Lake Superior basins are treated in the same manner.

The run-off per square mile has been plotted on the accompanying map, in the approximate location of the point of measurement. It is seen at once that there is a wide discrepancy in the low-water run-off in different parts of the state. A study of the rainfall will show that this was not the cause of the discrepancy. The rainfall records for the eight months ending August 31, have been plotted on the map, and the lines of equal rainfall drawn for each variation of 2 ins.

The greatest rainfall occurred in the upper valley of the Minnesota River, and reached 14 ins. or more. The run-off from this section was the lowest for any considerable area in the state, although conditions during the early spring were favorable for a comparatively high run-off during the low-water season. The snow came so early in the fall of 1909 that the ground was not frozen to any extent and consequently when the snow melted in the spring of 1910 the water was absorbed by the soil, instead of running off quickly, as it would have done had the ground been frozen.

There was a smaller area in the northeastern part of the state where the rainfall for the eight months reached 14 ins. Here the run-off was the highest for the state, but, as will be shown below, this was due not to the high rainfall but to storage. The area of least rainfall was the section surrounding Minneapolis and St. Paul, and here the run-off was at least as high as the average in other sections.

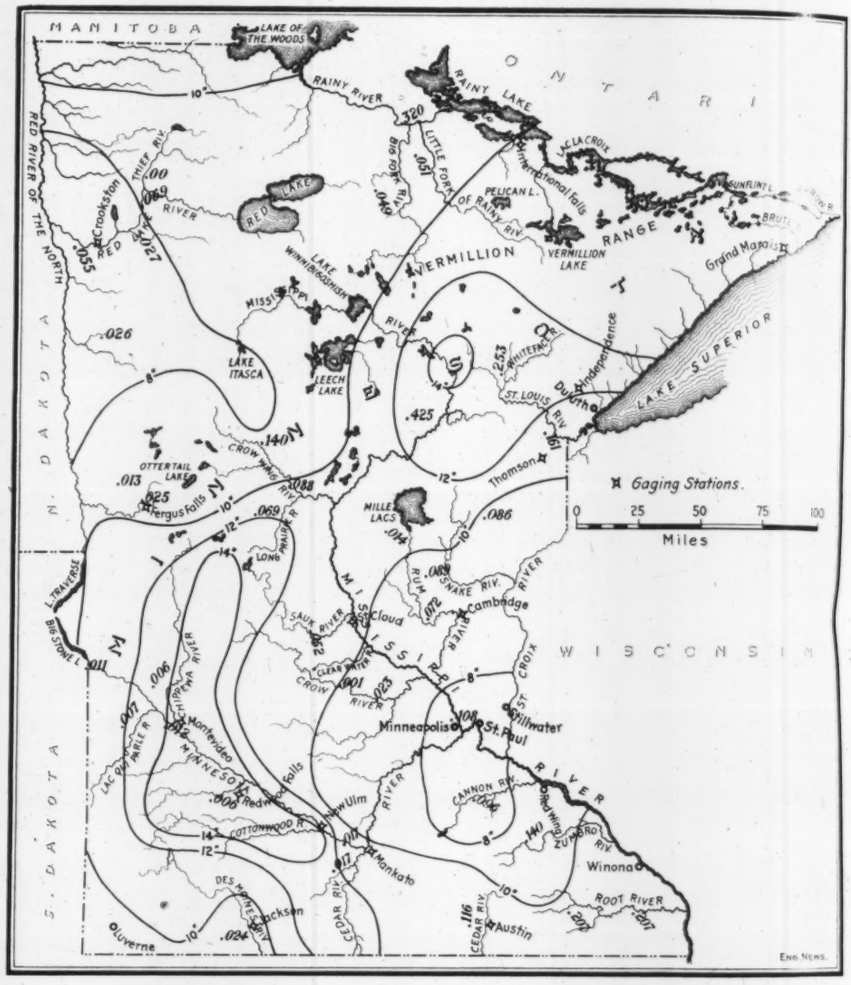
In general it may be said that the rainfall for the first eight months was from one-half to two-thirds the normal precipitation for that period, indicating its serious deficiency.

Excluding the Mississippi, St. Louis, Whiteface, Cloquet and Rainy rivers, the flow of which was artificially controlled by extensive storage, the run-off per square mile varied from zero in the Thief River Basin to .207 sec.-ft. in the Root basin. Adjacent to the latter basin, Cedar River had a flow of .116, while the larger basin of Red Lake River of which Thief River is tributary, gave a flow of .055 sec-ft. per sq. mi.

Main Characteristics of Principal River Basins.

To show more fully the variation in flow and explain the causes in many instances, each principal river basin will be taken up in some detail. Following the description of flow in the different basins will be found a table showing the percentage of total run-off to rainfall for the entire year 1910.

MISSISSIPPI RIVER.—This river, which is the largest in Minnesota, rises in a small lake above Lake Itasca (long considered its source) and through its upper stretch drains a region containing many lakes and large areas of swamp. The entire basin is covered with glacial drift. The Federal Government has constructed a system of five reservoir units to control the flow of the Mississippi in the interest of navigation. The following table (Ann. Rept., Chief of Engrs.,



MAP SHOWING RUN-OFF IN CUBIC FEET PER SECOND PER SQUARE MILE OF MINNESOTA STREAMS IN 1910 AND EQUAL RAINFALL CURVES FOR EIGHT MONTHS ENDING AUG. 31, 1910.

U. S. A., 1906) shows the area and capacity of these reservoirs:

Reservoir.	Area water surface, sq. mi. Low water.	High water.	Draft, ft.	Capacity, cu. ft.
Winnibigoshish (including Cass Lake).....	117	161	14	43,992,000,000
Leech Lake.....	173	234	5.7	33,094,300,000
Pokegama Falls..	24	25	7.5	5,200,000,000
Sandy Lake.....	8	16.5	9.4	3,157,900,000
Pine River.....	18	24	16.2	7,732,900,000

As these reservoirs are maintained primarily in the interest of navigation, they are operated in the following manner: When the river falls below the 3-ft. mark on the Weather Bureau gage at St. Paul, during the navigation season (April to October, inclusive) the reservoirs are operated in such a manner as to hold the water at the 3-ft. stage if possible. At the end of the season the flow is reduced to a uniform rate, which varies somewhat with the season and amount in the reservoirs, but rarely falls below 400 sec.-ft. at Pokegama Falls and 50 sec.-ft. each at Sandy Lake and Pine River.

*Published by permission of the Director, U. S. Geological Survey.

†District Engineer, U. S. Geological Survey, Old Capitol Building, St. Paul, Minn.

TABLE I.—COMPARATIVE MINIMUM MONTHLY RUN-OFF FOR MINNESOTA STREAMS, 1910.

(Cubic Feet per Second.)

River.	Station.	Drainage area, sq. mi.	Lowest monthly mean flow.	Run-off, per sq. mile.	Min. mean daily flow.
	Mississippi River Drainage.				
Mississippi	Sandy River	4,510	1,915	.425	....
Mississippi	Anoka	17,100	3,390	.198	3,110
Mississippi	St. Paul	35,700	3,850	.108	3,350
Mississippi	Nimrod	1,010	140	.140	120
Crow Wing	Pillager	3,230	283	.088	253
Crow Wing	Motley	973	67.4	.069	58
Long Prairie	St. Cloud	816	42.6	.052	24
Sauk	Rockford	2,520	58.5	.023	45
Crow	Near Forks	1,100	3.6	.003	2.5
South Branch Crow	Onamia	414	5.9	.014	3.5
Rum	Cambridge	1,160	84.2	.073	71
Rum	Odessa	1,560	16.5	.011	12
Minnesota	Montevideo	6,300	72.5	.012	49
Minnesota	Mankato	14,600	253	.017	240
Minnesota	Lac Qui Parle	677	5.0	.007	....
Lac Qui Parle	Watson	1,940	12.0	.006	11
Chippewa	Redwood Falls	703	4.4	.006	3.5
Redwood	New Ulm	1,190	9.3	.008	6
Cottonwood	Rapidan Mills	2,260	38.8	.017	21
Blue Earth	Sandstone	825	71.1	.086	36
Kettle	Mora	422	37.5	.089	33
Snake	Welch	1,290	124	.096	83
Cannon	Zumbro Falls	1,120	157	.140	148
Zumbro	Lanesboro	647	134	.207	....
North Branch Root	Houston	1,560	322	.206	285
Root	Austin	425	49.5	.116	20
Cedar	Jackson	1,160	27.5	.024	23
	Hudson Bay Drainage.				
Otter Tail	Fergus Falls	1,310	32.6	.025	16
Pelican	Fergus Falls	433	5.6	.013	2.6
Wild Rice	Twin Valley	805	21.0	.026	14
Red Lake	Thief River Falls	3,430	236	.069	....
Red Lake	Crookston	5,320	293	.055	170
Red Lake	Thief River Falls	1,010	0.0	.000	0.0
Thief	Red Lake Falls	1,310	35.7	.027	30
Clearwater	International Falls	14,200	4,540	.320	....
Rainy	Little Fork	1,720	88.4	.051	72
Little Fork	Big Falls	1,320	65.3	.049	34
Big Fork					
	Lake Superior Drainage.				
St. Louis	Thomson	3,420	549	.161	308
Whiteface	Meadowlands	442	112	.253	55
Cloquet	Independence	698	295	.423	82

Thus during the low-water period of 1910 the reservoirs were operating to increase the flow of the Mississippi. The effect of this operation is seen in the high run-off of .425 per sq. mi. above Sandy River, .198 at Anoka and .108 at St. Paul. The effect of the unregulated tributaries is seen in the lower run-off on the lower river. (In December the run-off at the same stations was .149, .113 and .063, respectively.)

CROW WING RIVER.—The source of Crow Wing River is the lower one of a chain of a dozen lakes located in Hubbard Co. At the outlet of these lakes, a logging dam is maintained for the purpose of driving logs down the river. During 1910 the log drive was delayed till late in the summer and thus the flow from the lakes was largely held back.

Of the 1,010 sq. mi. above the Nimrod gaging station, 612 sq. mi. are drained by Shell River, which is uncontrolled by artificial means, although being regulated naturally by a number of lakes within its basin. Shell River enters Crow Wing River between Nimrod and the logging dam, and thus the run-off from more than one-half the drainage area above Nimrod is uncontrolled.

The entire drainage basin of Crow Wing River is covered with glacial drift which is porous and which is the source of many springs found along the ravines and valleys, and upon the banks of the lakes. The area is forested for the most part, though much of the timber has been cut off.

The three gaging stations in the basin—at Nimrod and Pillager, on the main stream, and near the mouth of Long Prairie River—showed the minimum run-off to be .140, .088 and .069 per sq. mi., respectively. The effect of the natural regulation of the many lakes tributary to Shell River are seen in the higher run-off at the upper station, where the proportional area drained by Shell River is much higher than in the case of the lower station. Not only did the run-off from Shell River make up the loss of the water held back from the chain of Crow Wing lakes, but it greatly increased the run-off for the entire area above Nimrod over the run-off above the Pillager station on the lower river.

SAUK RIVER.—This river rises in Osakis Lake, in Todd Co., and drains an area of 821 sq. mi., of which 816 are above the gaging station. The upper half of Sauk River is the dividing line between the prairie and original forest areas. The forested area has been greatly reduced by clearing and cultivation, so that it now comprises but a small percentage of the entire drainage area.

There are three power dams above the gaging station which regulate the flow to a certain extent, but the available reservoir capacities are insufficient to withhold the flow for any great length of time. Thus, the discharge of .052 sec.-ft. per sq. mi. represents the natural run-off during the low-water period. (The flow increased in the fall, but fell off again in December to .025 sec. ft. per sq. mi.)

CROW RIVER.—Crow River, which is formed by the north and south branches, drains an area of 2,590 sq. mi. The basin is covered with glacial drift and is dotted with lakes of varying size. The area of 1,170 sq. mi. drained by the south branch had a minimum run-off of .003, while the run-off from an area of 2,520 sq. mi., representing both the north and south branches was .023 per sq. mi. The reason for the greater run-off in the latter case is due chiefly to the fact that the flow is controlled by a power plant at Rockford which has sufficient storage capacity, by sacrificing a portion of the available head, to increase the natural low water flow. Although the discharge of the two branches increased naturally during the fall, the flow of the main river below the dam, remained practically constant for the remainder of the year.

RUM RIVER.—Rum River, which has its source in Mille Lac Lake, drains an area of 1,550 sq. mi. The entire basin is covered with glacial drift. Granite outcroppings are found along the river. The upper half of the basin is largely cut-over timber land, while the lower half is cultivated land.

At the upper end of the basin a short distance below Mille Lac Lake the minimum run-off was .014 sec.-ft. per sq. mi., while at Cambridge, where the drainage area is 1,160 sq. mi., the run-off was .072. This variation is accounted for largely by the fact that of the 414 sq. mi. above the upper station, one-half (or 207 sq. mi.) is included within the shore line of Mille Lac Lake. This large proportion of water surface to tributary drainage area makes Mille Lac Lake a detriment to the extreme low-water flow of Rum River. The annual evaporation from the lake surface is approximately 33 ins., exceeding the normal rainfall upon the water surface by about 5 ins. In 1910 the rainfall for the eight months ending Aug. 31 was about 14 ins. The average evaporation for the first eight months of the year in Minnesota is about 25 ins., and as the summer of 1910 was dryer and warmer than normal it is probable that the evaporation exceeded the average. In any event, the excess of evaporation over rainfall during 1910 was 11 ins. or more, which had to be made up by the run-off from the tributary area. This, of course, reduced the run-off from the lake, and more than offset the increase to the low-water flow through the natural regulation of the lake.

MINNESOTA RIVER.—The area drained by Minnesota River comprises 16,600 sq. mi., extending nearly across the southern part of the state. With the exception of the Minnesota valley below Mankato, the lower part of the Blue Earth valley, and those of one or two other smaller tributaries, the drainage area is covered with glacial drift, with very little rock outcropping. The surface is flat or gently undulating, except on the southern boundary, where it rises several hundred feet to a table land. The greater part of the basin is prairie land with very little timbered area.

The minimum run-off in the main river increased from .011 a short distance below Bigstone Lake to .012 at Montevideo, and to .017 at Mankato. Points on tributary streams showed a run-off of .006, .007, .008 and .017 per sq. mi. With the exception of the latter run-off, which was that of Blue Earth River, the tributary run-off was about one-half that of the Minnesota itself. It is probable that the increased run-off for the latter stream was due to the regulating effect of Bigstone and Marsh Lakes and Lac Qui Parle, through which the river flows. As the areas of these lakes are only a small proportion of the drainage areas above them, the evaporation from their water surfaces does not offset their natural regulation of the run-off, as was found in the case of Mille Lac Lake.

The higher run-off of .017 found on the Minnesota at Mankato is probably explained by the fact that a few miles above this point the river cuts through the glacial drift and flows in a preglacial valley. From the sides of this valley frequent springs issue. Below Chippewa River there is no important tributary entering from the north, and consequently the surface run-off from this area is very small. Thus the increased run-off at Mankato must come largely from underground sources.

The 3,430 sq. mi. drained by Blue Earth River comprise an area which has numerous lakes in its upper portion. It is traversed by many streams which afford ready access to the lakes and main river for the surface run-off. There are many artesian fountains in the basin, showing the presence of a considerable underground water-supply. The minimum run-off from the basin was .017 per sq. mi.

ST. CROIX BASIN.—St. Croix River drains an area of 7,140 sq. mi., lying in Minnesota and Wisconsin. The discharge of the main river was not measured in 1910, although records of flow were kept on two Minnesota tributaries. Conditions of flow in the Minnesota section of the area are so different from those in the Wisconsin area that results obtained from one would not apply to the other. The Minnesota portion of the area is covered with glacial drift with very little rock outcropping except along Kettle River. This stream, which drains 1,030 sq. mi., gave a minimum run-off of .086 per sq. mi., and Snake River, whose drainage area is 948 sq. mi., gave a run-off of .089. These results show a uniformity in low water run-off between the two streams that is rarely found in the state.

The flow of Kettle River is not controlled to any extent, while that of Snake River is controlled to a certain extent by two logging dams above the gaging station. There are very few lakes within the Minnesota area drained by the St. Croix. (In December the run-off of Snake River above the gaging station at Mora fell to .043, due probably to the closing of the logging dams.)

CANNON RIVER.—This river drains an area of 1,490 sq. mi., covered with glacial drift, except in the valleys of the Cannon and its tributaries, which are cut deep into the underlying rocks. This penetration of the rocks has uncovered many springs which are found in the sides of the bluffs. Straight River, the principal tributary, has its source in the many springs of the morainic hills which limit its upper boundary. There are few lakes in the basin, and very little timber, as the land is practically all under cultivation. The largest lake is Cannon Lake, which lies in the channel of the river. It is used as a reservoir for power, but as its tributary drainage area is only 274 sq. mi., its influence on the low-water flow for the entire basin was slight. The minimum run-off was .096

per sq. mi., which shows the effect of the underground source of supply.

ZUMBRO RIVER.—Zumbro River drains 1,390 sq. mi., which area is practically all under cultivation. The general surface of the basin is undulating, except for the river valleys, which are cut through the glacial drift into the underlying rocks. These rocks are the source of numerous springs which tend to keep up the low-water flow, as shown by a minimum run-off of .140 sec.-ft. per sq. mi. There are no lakes or artificial reservoirs of any size in the basin to regulate the flow, so the comparatively high run-off was due to the underground supply.

ROOT RIVER.—This river, which drains 1,560 sq. mi. in the southeastern corner of the State, approached nearer its normal flow during 1910 than any other stream that was not artificially regulated. Throughout its entire length, and that of many of its tributaries, the flow is in a gorge-like valley that is deeply cut through the glacial drift, into the underlying rocks. In these rocks, as in the case of the Cannon and Zumbro rivers, (except to a greater extent), are found many large springs which give the river its uniform flow. The two records in the basin, one of which is for the north branch of the Root and the other for the lower portion of the main river, showed a minimum run-off of .207 and .206 per sq. mi., respectively. There are neither lakes nor artificial reservoirs to increase the low-water flow through regulation. The entire basin is under cultivation, except the sides of the bluffs bordering the stream, which are timbered.

CEDAR RIVER.—Cedar River drains 602 sq. mi. above the Minnesota-Iowa line. As there are few lakes in the basin there is no natural regulation of flow from that cause. Although the river does not penetrate the underlying rock, and thus get the benefit of the underground water from that source, the morainic tracts in the western portion of the drainage basin undoubtedly furnish an underground supply of water. This accounts largely for the run-off of .116 per sq. mi., which is higher than that for any other unreservoired area in the State, with the exception of the Root and Zumbro, which tap the large underground supplies in the underlying rocks. There are a number of small power plants on the stream and their combined pondage helped the low-water flow.

DES MOINES RIVER.—The area drained by Des Moines River above the Minnesota-Iowa State line is 1,220 sq. mi. This drainage basin is entirely covered with glacial drift and is in the prairie section of the State, with no timber except on the margins of the rivers and of the lakes. Of the latter, Lake Shetek is within the course of Des Moines River, and a second, Heron Lake, discharges into it. The headwaters of the Des Moines River rise in the high table land known to geologists as the Coteau des Prairies, and as this is an open mouth for the underground reservoirs within and below the drift sheet it is probable that this accounts chiefly for the minimum monthly run-off of .024, exceeding by 300 or 400% that obtained from the area directly north, which is tributary to the Minnesota River from the south—this in spite of the fact that the rainfall, as shown by the accompanying map, was slightly greater in the latter case. The discrepancy between the minimum run-off for Des Moines basin and that of the Cedar basin cannot be readily accounted for unless it is due to the operations of the small power plants mentioned, the only known physical difference being that the mean annual rainfall in the latter case is 2 or 3 ins. greater. During 1910 the rainfall for the two areas was very nearly equal.

RED RIVER.—The area of 34,300 sq. mi. which is drained by Red River above the international boundary line represents such diverse conditions and run-off that the various sub-areas will be described separately. The records on the main river at Fargo and Grand Forks, which showed a monthly run-off of .008 and .017, respectively, are not shown on the accompanying map, as approximately one-third of the drainage area lies in North and South Dakota, with radically different conditions of flow.

OTTERTAIL RIVER.—The upper portion of Red River is known as Ottertail River and heads in a small lake in the southwestern part of Clearwater Co., only a few miles from the source of the Mississippi. Throughout its course, until it is joined by the Bois des Sioux River, it flows through eight or ten lakes, most of them containing several square miles and the largest of which (Ottertail Lake) contains 22 sq. mi. In addition to the lakes in the course of the river itself, there are several hundred others of varying size in the basin. Many of these lakes have no visible outlet except during high water. The basin is very rolling and deeply covered with glacial drift in which little or no rock outcropping is found. The upper third of the area is timbered land which has been largely cut over, while the lower two-thirds is cultivated land, for the most part. The many lakes through which the river flows have a regulating effect which prevents wide ranges of stage. On the upper course, above Frazee, there are a number of logging dams which control the flow, but on the lower course the natural regulation of the lakes destroys the effect of the logging dams. At two places in the basin are records available. These show .025 per sq. mi. on the Ottertail itself, and .013 on the Pelican, which is a tributary draining 450 sq. mi. The low-water flow of this latter stream is controlled largely by a mill at Elizabeth, a few miles above the gaging station.

WILD RICE RIVER.—This river drains an area, of 1,440 sq. mi., which is rolling prairie, except the upper third of the basin, which is heavily timbered. There is a logging dam at the outlet of lower Rice Lake, which controls the flow from 128 sq. mi., and one at the outlet of Twin Lake controlling the flow from a much smaller area. These two dams control the run-off from less than one-quarter of the area above the gaging station, so their influence is not felt to any great extent. During the low water of 1910, when the run-off at the one gaging station was .026, it is believed that the dams were both open, the flow being too small to attempt log driving.

RED LAKE RIVER.—Red Lake River is the most important tributary of Red River and carries a larger amount of water than the latter, above the junction. The area drained by Red Lake River is 5,760 sq. mi., of which the upper 4,000 sq. mi. is timbered, while the remainder is prairie land, the greater part of which is under cultivation. Of the total area, that drained by Thief River (1,030 sq. mi.) did not contribute any flow during the latter half of the year—the water being held on the upper river by temporary dams for the use of floating dredges engaged in extensive drainage operations. At two points on the main river and at one point on Clearwater River, the principal tributary records of flow were kept. These showed the run-off to be .069 just below the mouth of Thief River, and .055 at Crookston. The run-off from the 1,310 sq. mi. drained by Clearwater River was .027. The low-water daily flow of Red Lake River is materially affected by power dams at Thief River Falls, Red Lake Falls, and Crookston, though the water cannot be held back for any length of time owing to insufficient reservoir capacity. Thus the monthly mean during the low water was but little affected. The chief reason for the comparatively high minimum run-off is Red Lake, which is the source of Red Lake River, and which has an area of 1,950 sq. mi. above its outlet, of which 441 sq. mi. represent the lake area. (The flow of Red Lake River gradually decreased throughout the remainder of the year and was somewhat lower during December than the figures given above).

RAINY RIVER.—The name Rainy River is applied to the stretch of the northern boundary waters that connects Rainy Lake with Lake of the Woods. At its mouth it drains 20,400 sq. mi., and at its source in the outlet of Rainy Lake, the drainage area is 14,200 sq. mi. This area, which is timbered, is thickly dotted with lakes, the largest being Rainy Lake, which covers about 344 sq. mi. The effect of this natural reservoir system, which is further increased by the power dam at International Falls controlling the water level of Rainy Lake to a certain extent, is seen in the high minimum run-off of .320 per sq. mi. About Rainy Lake the drainage comes from the region of bare rocks, as the glacial drift which covers the greater portion of Minnesota does not extend that far east.

LITTLE FORK RIVER.—This is the largest tributary of Rainy River from the Minnesota side, and drains an area of 1,900 sq. mi. The basin has a slope northward which is insufficient to afford good drainage and consequently there are large areas of swamp. The area is heavily timbered, though much of it has been cut over. There are a number of lakes in the upper portion of the basin. The flow of the river is wholly uncontrolled except for the limited natural storage afforded by the small lakes on the headwaters. At only one point in the basin are records available, and these showed a minimum run-off of .051 per sq. mi.

BIG FORK RIVER.—The area of 1,840 sq. mi. drained by this river which lies directly west of the Little Fork basin is similar to it in all respects, except that it rises in two lakes having a combined area of about 30 sq. mi., but having only an area of 259 sq. mi. tributary to their outlet. This small tributary area prevents the lake storage adding materially to the low-water flow for the basin as a whole, as the record at Big Falls (1,320 sq. mi.) showed a run-off of .049 per sq. mi.

ST. LOUIS RIVER.—This river, which drains an area of 3,440 sq. mi., chiefly in St. Louis Co., empties into Lake Superior at its head. The entire basin is covered with glacial drift. Owing to the flatness of much of the basin it contains large swampy areas of muskeg, through which there is a slow obstructed drainage to the rivers. The entire basin is timbered land, which has been cut over, largely. There is very little cleared and cultivated land in the entire basin. There are many logging dams on the St. Louis and its tributaries. These dams control the flow from about 950 sq. mi., or 27% of the entire area. In addition to these, there is a service reservoir of the Great Northern Power Co. located at Thomson. This reservoir has a capacity of 130,000,000 cu. ft., and thus is not capable of seriously controlling the flow for any length of time. At three points in the drainage basin, on St. Louis, Whiteface and Cloquet rivers, records were maintained during 1910 which showed the minimum run-off to be .161, .253 and .423 per sq. mi., respectively. Due most probably to the closing of the logging dams for the winter, the flow of St. Louis River in December fell to .082, as compared to .161 during the summer months. This illustrates forcibly the fact that water stored for logging purposes is in many instances a hindrance to power development, rather than a help, as the flow is frequently held back during the winter period—the season when it is most needed for power purposes.

TABLE II.—RELATION OF TOTAL RUN-OFF TO TOTAL RAINFALL, MINNESOTA STREAMS, 1910.

River.	Run-off depth, ins.	Rainfall on basin, ins.	Per cent. of run-off to rainfall.
Mississippi River Drainage.			
Mississippi above Sandy River	5.79	16.25	35.6
Mississippi at Anoka	3.62	15.33	23.8
Mississippi at St. Paul	2.61	15.44	17.2
Crow Wing at Pillager	3.55	15.48	22.9
Long Prairie near Motley	2.22	15.48	14.5
Sauk near St. Cloud	1.96	14.22	13.8
S. Branch Crow near Rockford	1.43	13.00	11.0
Crow at Rockford	1.50	13.04	11.5
Rum at Onamia	2.97	14.63	20.3
Rum at Cambridge	2.41	14.42	16.7
Minnesota near Odessa	.85	15.50	5.5
Minnesota near Montevideo	.94	16.00	5.9
Minnesota near Mankato	1.28	15.95	8.0
Cottonwood near New Ulm	1.18	17.00	7.0
Blue Earth at Rapidan Mills	2.24	15.42	14.5
Kettle near Sandstone	3.78	15.00	25.2
Snake at Mora	2.82	14.00	20.2
Zumbro at Zumbro Falls	3.75	12.47	30.5
Root near Houston	3.27	16.53	19.8
Cedar near Austin	3.58	15.97	22.4
Des Moines at Jackson	1.06	14.35	7.4
Hudson Bay Drainage.			
Ottertail near Fergus Falls	2.08	13.93	14.9
Pelican near Fergus Falls	2.20	13.70	16.0
Wild Rice at Twin Valley	2.60	12.83	20.2
Red Lake at Thief River Falls	3.05	13.30	22.9
Red Lake at Crookston	3.02	12.40	24.3
Thief near Thief River Falls	2.67	14.00	19.1
Clearwater at Red Lake Falls	2.57	12.80	20.0
Little Fork at Little Fork	3.81	18.80	20.3
Big Fork at Big Falls	6.36	18.20	35.0
Lake Superior Drainage.			
St. Louis near Thomson	4.50	18.10	24.8
Whiteface at Meadowlands	6.34	18.10	35.0
Cloquet at Independence	8.69	18.00	48.2

Relations of Total Run-off to Total Rainfall for Year 1910.

The preceding discussion has dealt solely with the minimum monthly run-off. To show the relation of total run-off to total rainfall for the entire year, Table II. has been compiled. In the first column of figures the mean discharge for the year has been changed into its equivalent depth in inches over the entire drainage area above the point of measurement. That is, if the total flow past each gaging station were stored, it would cover the entire drainage basin to that depth in inches. The next column represents the mean rainfall in the basin above the gaging station, as determined from the rainfall records of the Weather Bureau. The last column shows the percentage of the rainfall that appeared as stream flow.

It is readily seen that in the drainage basins which were swampy, or timbered, or both, such as the Crow Wing, upper Rum, Kettle, Snake, Wild Rice, Red Lake, Clearwater, Little Fork, Big Fork and St. Louis basins the run-off exceeded 20% of the rainfall, while in the basins having little or no swamp, or timber, such as the Crow, Minnesota and Des Moines basins, the total run-off was very much less—ranging from 5.5 to 11.5% of the rainfall. The remaining basins, which are not included within those already mentioned, lie between the two classes, and hence their percentage of run-off is between those of the others.

The Mississippi, above Sandy River, although draining a basin of wooded swamp largely, had its run-off increased by water from previous years, stored in the Government reservoirs.

The Zumbro, Root, and Cedar basins, although containing little swamp or timber had a run-off comparable with the basins of the first class on account of their large underground sources of supply which originate beyond the boundaries of the basins themselves.

Freight Handling Installations for Rivers Subject to Great Variations in Level.

By G. C. SCHERER.*

With the increased navigation on freshet streams, resulting from extensive public improvement, and the growing production of their contributing territory, the treminal facilities for loading and unloading barges have become a very live issue. On large rivers, where a reasonable stability of level may be expected, the loading problem has been quite extensively studied, although only a few really complete plants have been installed, but on the smaller streams, where traffic is occasional and where the river level will vary from 15 to 40 ft. in a few days, very few attempts have been made to provide suitable accommodations. The problem here becomes more complicated, both from economic and engineering reasons. There are presented herewith three different solutions of this latter problem.

Fig. 1 represents a possible terminal where the banks of a river are steep and practically perpendicular. By the extension of trestle work this method, however, can be used where the banks are very sloping. This method consists of a spur track on piling parallel with the river banks, placed sufficiently high above extreme flood stages to preclude possible inundation. On this spur track is operated a traveling crane by which cars placed on another track parallel to the first, or crane track, may be discharged either onto barges or into a warehouse by the use of kips or grapples, depending on the character of material to be handled. Should it be desired to handle coal or ore, tipples may be provided.

The use of a traveling crane is considered as giving the best results, owing to the ease with which work may be performed at any point on the crane track. It also prevents the necessity of moving boat or barge, which at times is most undesirable. The operating machinery for lifting should also be so arranged that the crane structure be self-moving, thus saving time and the cost of additional labor in moving crane from one point to another on the crane track. Empty and loaded cars may also be shifted with ease by the same means. The trestle work should be sufficiently rigid to prevent oscillation when lifting machinery is in operation.

This installation is applicable only where the volume of freight permits permanent structures to be erected.

Fig. 2 represents an arrangement for transfer of freight at way landings where necessity demands cheap installation. This consists of a light cableway, which is carried aboard the boat, and which may be installed quickly by two or three deck hands. River boats are usually provided with hoisting machinery, though of small capacity, but large enough to handle such freight as is offered at way landings, and this hoisting machinery, using steam from the permanent installation aboard, makes the cost of operation negligible. When a landing is reached, one end of the cableway is carried ashore and made fast to a post previously installed, or to a convenient tree, the other end remaining fast aboard ship. The slack of the cable is then taken up by the drum provided for hoisting, thus providing a rigid overhead cable upon which a carrier is operated in the usual way.

This method is peculiarly adapted for way landings where the volume of freight is small or remittent. The cost should be exceedingly small. Should the time consumed in installing this cableway be of too great importance, the small cost of cable and trolley permits installation at the different points, then requiring only the tightening of cable on arrival of the boat. Care should be exercised that the cable, when not in use, be not allowed to sag into the water and thus rapidly deteriorate.

Fig. 3 represents a ramp arrangement with railway connections. This arrangement consists of an endless belt conveyor, electrically operated by self-contained motor, having a walkway alongside. This arrangement can be operated at any stage of water, being hoisted or lowered as required; on streams where the fall or rise of water is rapid, this arrangement is believed to be ideal, permitting work of loading or unloading to progress without interruption.

The same machinery that is used for loading or unloading may be used to operate the ramp. This arrangement, however, could only be used where the volume of freight would justify its costly installation. The cost of installation would vary, dependent on local conditions.

In general, the transfer of freight is estimated by various railroads to cost from $1 to $15 per ton on the Mississippi River, and from perhaps 50 cts. to $1 per ton in New York harbor, and the transfer from boat to rail at harbors on the Atlantic and Gulf coasts. Modern installations have, in almost all cases, reduced this by possibly one-half.

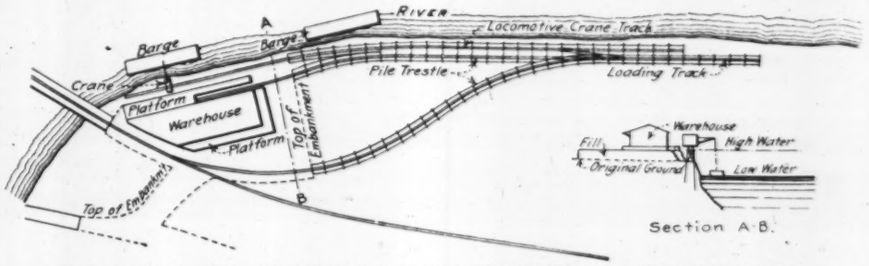


FIG. 1. TYPICAL FREIGHT HANDLING PLANT ADJACENT TO RIVER WITH VARIABLE LEVEL USING TRAVELING CRANE.

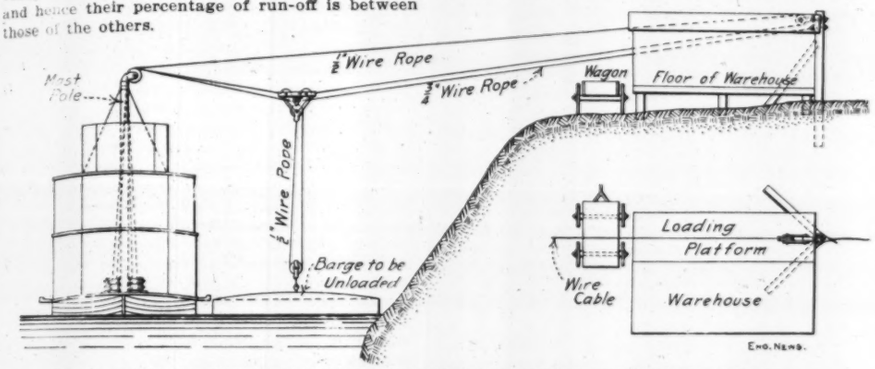


FIG. 2. TYPICAL PORTABLE CABLEWAY INSTALLATION FOR HANDLING FREIGHT.

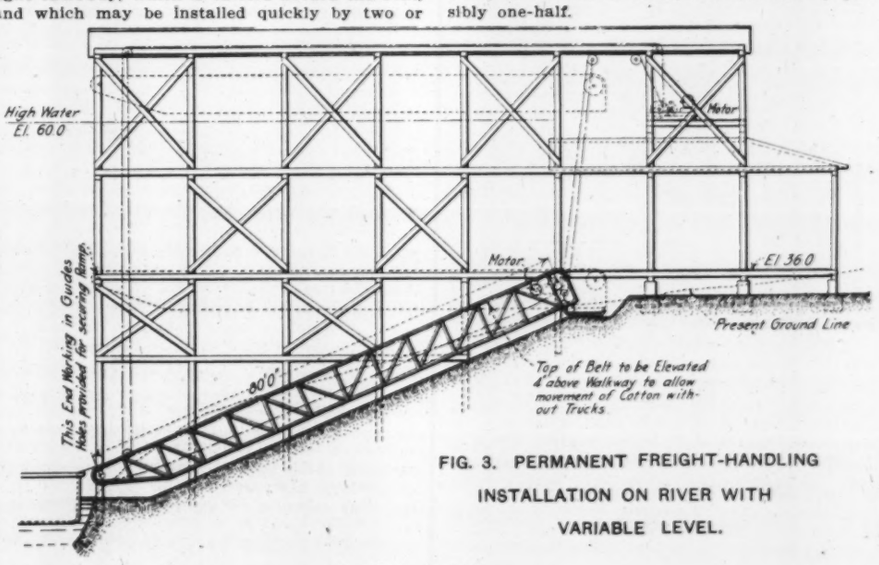

High Water El. 60.0
Motor
Motor
El. 36.0
Present Ground Line
This End Working in Guides Has provided for Securing Bumps.
60'0"
Top of Belt to be Elevated 4' above Walkway to allow movement of Cotton without Trucks

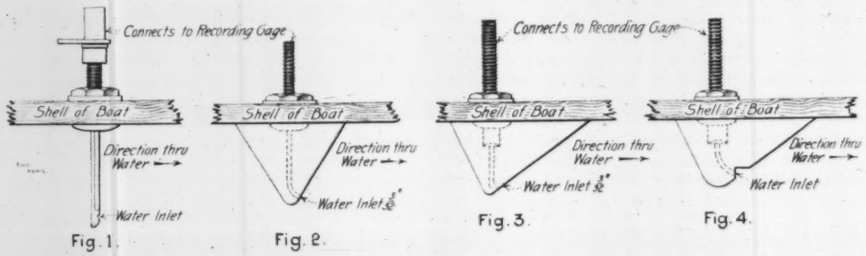
FIG. 3. PERMANENT FREIGHT-HANDLING INSTALLATION ON RIVER WITH VARIABLE LEVEL.

*Montgomery, Ala.

The Pitot Tube as a Marine Speedometer and Its Development.

By FRANK B. SANBORN,* M. Am. Soc. C. E.

The purpose of the marine speedometer described in this article is to indicate the speed, in miles per hour, of motor boats, cruisers or yachts. It is not a revolution counter; but acts independently of engine or shaft. The speed is shown on a gage which resembles a water or steam pressure gage, and the gage reading is produced by pressure of water which enters a form of pitot tube that projects through the bottom of the boat. This inlet tube with its cutwater has been especially designed to resist impact with floating objects, to prevent obstruction and to make it possible to clear away easily any that may happen to occur.



FIGS. 1-4. EARLY FORMS OF PITOT TUBE INLETS FOR MARINE SPEEDOMETER.

THE INLET TUBE.—A person who has not experimented with such inlet tubes can only slightly appreciate the manifold difficulties that arise by breakage and numerous interferences when such devices are placed on ordinary boats that cruise in shallow or dirty water. Even these difficulties are materially increased in the modern speed boat, which in some models draws very little water, actually skimming over the surface, striking pieces of wood, grass, bottles and the like.

During the past three years I have experimented with various forms of inlet tubes, endeavoring to develop one that would not be bulky, easily obstructed, nor broken when used under adverse conditions of shallow draft, high speed and dirty water.

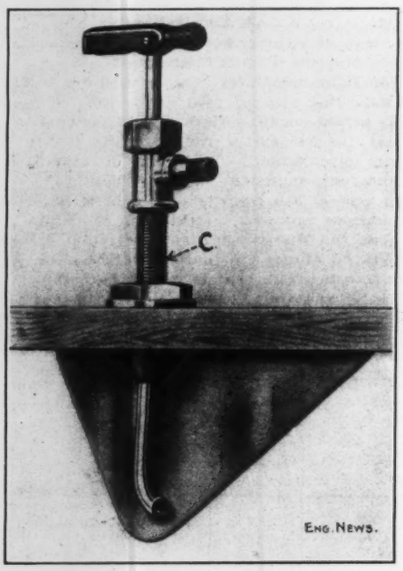


Fig. 5. Final Form of Pitot Tube Inlet.

A few of these experiments will be briefly described. First a slender tube of the form shown in Fig. 1 was tried. Some of its advantages were: that it caused little resistance to water; in case it was hit, it would bend or break without damaging the shell of the boat; it could be withdrawn into the boat and thus examined and freed of obstructions; it required only a ⅝-in. hole through the shell of the boat, and it could be easily attached.

Trials showed that the accuracy of this form was satisfactory. When used in water free from grass and floating materials, or when used in deep water, it would continue to operate uninterruptedly; but when used on a shallow-draft speed boat it was apt to become obstructed.

Out of twelve experimental ones that were tried in various parts of the Eastern States, three had occasional troubles, which were as follows: One used throughout the season at Boston on a boat making 17 miles per hour and drawing 3 ft. of water had to be unscrewed and cleaned three times during the season. On one occasion grass and seaweed became wound around the vertical stem making a ball 3 or 4 ins. in diameter; at other times it stopped temporarily due to obstructions, but afterward freed itself. Another one was tried at Bangor, Me., where the water contained an unusual amount of sawdust and floating pieces of bark; here frequent obstructions occurred causing serious interruptions. A third one was used on a 25-ft. boat having a speed 16 miles per hour, and when running at full speed the forward half of the boat was raised out of water. The first device tried here was hit and broken off when it had been in use only a day or two, another was substituted and similarly was broken immediately afterwards. These experiences show some of the difficulties that have arisen in the use of a slender form of inlet tube.

A more rigid form and one of different shape was tried next. (See Fig. 2.) In this form no provision was made whereby the inlet tube could be cleaned by removing it from under the boat. The object sought was to ascertain what obstructions might occur, and the extent of provision that should be made to prevent both obstruction and breakage.

The tube was protected by a thin plate *P*, which had rounded edges. It was believed that grass, seaweed, or particles of mud or sand would not obstruct the inlet and that larger material, like twigs and pieces of wood, would be thrust aside without causing obstructions. Actual trials, however, did not verify these expectations. Although sand, mud, or grass were not serious enough to cause stoppage, they were an annoyance, and caused partial obstruction of the inlet.

It was not uncommon to have readings obtained with this form of inlet quickly drop from a correct speed indication to half that amount or in other cases to zero. This interruption and irregularity was, I think, attributable to the small size inlet opening, in this case 3/32-in. diameter.

Pitot tubes with openings smaller than this were used by early experimenters; by Freeman in determining the velocities of different parts of a stream from a nozzle, and by Williams, Hubbell and Fenkell in experiments for finding the velocities in water mains. Under the conditions that these experiments were made, the sizes of openings were doubtless suitable, but where muddy or dirty water is encountered these small openings, according to my experience, are apt to give trouble.

From experiments made at the University of Illinois in 1909, with a tube having a 1/16-in. opening, I found that particles of thread, which evidently came from cotton waste, would wholly or partially obstruct the inlet passage. I mention this instance to show the difficulties that are experienced with a 1/16-in. opening even in laboratory tests with fairly clear water. On motor boats in both salt and fresh water greater difficulties arise. Furthermore, in the use of motor boats, difficulty may arise ,not only by small particles that lodge at the inlet, but even pieces of wood may be driven into the tube so as to wholly obstruct the inlet. An instance of this sort occurred last summer during tests on a speed boat that was equipped with a device like that shown in Fig. 2. As a result of these experiments I was convinced that at least two conditions should be fulfilled in any satisfactory inlet for a speedometer; first, the inlet should be materially larger than 1/16-in., and secondly, it should be protected from coming in contact with floating objects.

In order to determine how the reading might be affected by the slope of the metal plate or protector that extends in front of the inlet tube a test was made with the one shown in Fig. 3. The front edge of this plate was rounded slightly, thus giving some opportunity for currents of water to pass downward in front of the inlet. The result was that with this slope a boat that previously registered 16 miles an hour, now registered 12, and apparently the difference was wholly due to the above change in slope.

The next form tried was the one shown in Fig. 4. The tube used in this case was ¼-in. diameter, or twice the size of the previous ones, and the inlet was cut back as shown, so as to be protected from the impact of floating materials and not be materially affected by downward currents. This form was found to fulfill all requirements fairly well. It registered accurately and became obstructed only rarely, even in Boston Harbor on a boat running 12 to 17 miles an hour. It had, however, no ready means of clearing the tube in case obstructions did occur, and largely on this account the final form shown in Fig. 5 was developed.

In Fig. 5 the inlet tube is back of the protecting plate *P*, where it can only be hit by objects that may pass along close to the side of the plate. The tube opening is ¼-in. in diameter and on that account not easily obstructed. Furthermore, the clearing wire *C* can be operated to remove any obstruction that may occur. This clearing wire remains in the tube and has an adjustable handle which serves to fix it in position above the inlet when not in use and as a convenient grasp for the hand when the wire is being forced through the tube to remove obstructions. It will be noticed that this method of clearing requires no disconnecting of pipes or fittings nor the insertion of extra parts. In tests, however, that were made during last season, obstructions did not occur with this final form of inlet which required the use of the clearing wire for their removal.

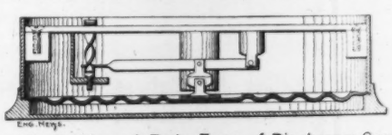


Fig. 6. Section of Early Form of Diaphragm Gage.

In the past, open ends of pipes or some form of scoop have been used for receiving water pressure. For fast boats of modern design it is objectionable to have any such tube or pipe placed where it will offer material resistance to the passage of the boat through water. The total thickness of the tube and cut-water here shown is ⅜-in., and this is probably about as bulky as should be adopted.

THE RECORDING GAGE.—Besides a device for receiving water pressure, it is important to have a simple and reliable recording apparatus to show the speed of the boat in miles per hour or in other units. I experimented in the summers of 1908-'09 with a form of water column that served for low speeds of 5 to 8 miles per hour, and with mercury columns for higher speeds. I found neither method satisfactory in rough or choppy water. Moreover, the chances of breaking a glass tube arranged as a U column or like an ordinary thermometer are appar-

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Graduations cannot be made as conspicuous and easy to read on a tube or scale 12 ins. long as on a dial 6 ins. in diameter. For boats that run 20 miles an hour, a mercury column placed near the water level must be 11 ins. long, and for 30 miles an hour it must be 24 ins. long. For these reasons it has seemed best to use some form of dial pressure gage; but since the range of pressure is from zero to a maximum of 15 lbs.

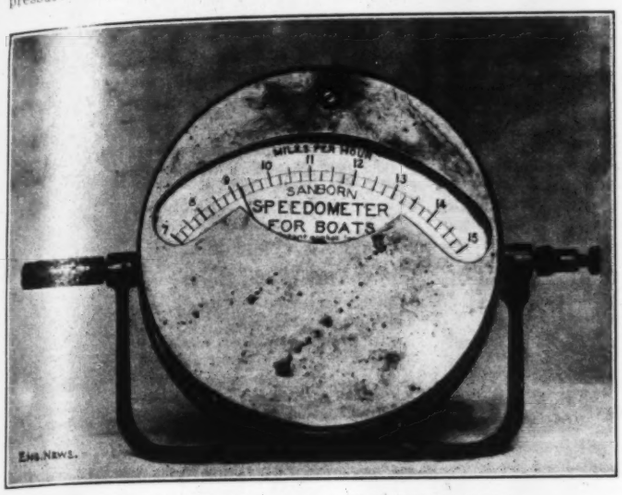

FIG. 7. EARLY FORM OF DIAPHRAGM GAGE.

per sq. in., and the average boat requires readings only from 0 to 5 lbs., it is evident that the ordinary Bourdon pressure gage would not be sensitive enough. Hence a diaphragm gage has been developed to meet these requirements.

The present form is the result of extended trials, failures, changes and eliminations. The difficulties to be overcome and the requirements of accuracy under varying conditions were: sensitiveness, but not delicacy; transportability without injuring the adjustment; and finally, these requirements to be accomplished without making a bulky device. One of the first diaphragm gages improvised in the spring of 1909 was fairly satisfactory except that it was too bulky.

Various changes were then introduced to simplify and compact the mechanism and case. These changes included tests with rubber diaphragms, tin-foil diaphragms, and various qualities of brass and bronze until finally a phosphor-bronze has been selected which possesses the required qualities of elasticity, strength and durability.

To transmit the movement of the diaphragm into a circular motion in a plane parallel and close to it, gave unusual difficulties. It seemed to the writer that the form of transmission used in aneroid barometers, although working very sensitively and satisfactorily in scientific instruments, would be ill adapted to rough usage on motor boats. For this reason a form of motion was tried similar to that used on certain forms of screw drivers, by which rotation is produced by a simple thrusting motion. This gage is shown in Figs. 6 and 7. This form of gage was later abandoned for the final form shown in Fig. 8.

In the final form the supporting bracket was materially changed from earlier designs so as to bring the inlet pipe or tubing near the base, and to allow the gage to be fastened to the floor or a partition and tipped to any angle convenient for reading.

The internal mechanism consists of an ordinary gage movement and a crown gear, similar to that in some stem-winding watches, for changing the rotation to a plane parallel to the diaphragm. Thus no novel or untried parts were introduced into the mechanism and we have from diaphragm to pointer positive connections independent of frictional contact.

The gage shown in Fig. 8 is 4½ ins. in diameter, and when tested in the laboratory for a pressure of ½-lb. per sq. in., is accurate within 4%, and for pressures over 1 lb. per sq. in., within a fraction of 1%.

The gage is placed preferably amidships and from 12 to 24 ins. above the water line. Connection is conveniently made from the gage to the inlet by means of a ¼-in. copper tubing which may be cut to any length and joined to the gage by means of a flared union joint. For most boats a gage so placed and connected will read, when first installed, approximately the speed in miles per hour, but since boat models and currents under the hull vary for different conditions, it is desirable to test the speed by running over a measured course. When this has been done, if it is found that the reading needs correction, an adjusting screw will turn the pointer so as to give a correct reading. This adjustment is made in a manner similar to that of moving the pointer to the zero mark on ordinary postal scales.

Thus the speedometer can be set to read accurately the true speed of a boat in miles per hour, and be of material assistance during long runs in the open or for gaging distances that are run in fog. It is also valuable for indicating changes in speed that may be produced by varying the carburetter, the air and gasoline mixture, and the revolutions of the engine. It will indicate the effect that different propellers, varying amounts of ballast, sizes of spray hoods, or tenders in tow, may have on the speed of a boat.

THE LARGEST CAR-FERRY STEAMER in the world is said to be "Ann Arbor No. 5," built for the Ann Arbor Ry. service on Lake Michigan, between Frankfort, Mich., and Manitowoc, Wis. It is 378 ft. long, 56 ft. beam and with 17 ft. 4 ins. clear height from the car deck to the upper deck. The tonnage is 1,961 net and 2,884 gross. The track capacity is 30 cars, with an average length of 42 ft. The stern is open to permit of running cars in and out, but this can be closed to a height of 5½ ft. above the car deck by means of a heavy apron. This will protect the vessel

Fig. 8. Present Improved Gage of the Sanborn Marine Speedometer.

from being "pooped" by heavy following waves in a rough sea. The vessel is heavily built in order to maintain the service in winter, and in proceeding to Frankfort from Toledo last winter it worked its way through ice 18 to 24 ins. thick. The twin screws are 12½ ft. diameter driven by triple expansion engines, and steam is supplied by four Scotch boilers. The steamer was built by the Toledo Shipbuilding Co. to the designs of Mr. Frank E. Kirby. Although work was not commenced till Sept. 3, the hull was launched on Nov. 26, and left the shipyard complete on Jan. 11, 1911.

Advantages of Long-Stroke Gasoline Engines for Commercial Vehicles.*

By EDWARD A. MYERS.†

In noting the views from time to time of different writers on the subject of length of stroke in gasoline engines, we have been able to find a great diversity of opinion and plenty of claimed advantages in both long and short-stroke types, but unfortunately it has been almost impossible to find any lucid explanation of these advantages or disadvantages. They have been given as conclusions and we are expected to accept them as facts without explanation. In discussing the relative merits of long and short-stroke engines, it is here proposed to treat them from the standpoint of theory as well as from the standpoint of practical experience.

Fifteen years ago we designed and built our first line of single-cylinder stationary engines, which we would now call medium short-stroke engines. They included the following sizes: (In order to avoid repetition of the words "bore" and "stroke," we give the cylinder diameter first; stroke second.)

5 × 6, 7 × 9, 11 × 15, 17 × 26.

After building these sizes for four or five years, we then conducted a series of tests with motors of various bore and stroke, which resulted in our bringing out long-stroke single-cylinder engines in the following sizes:

5 × 8, 7 × 11, 10 × 18, 17 × 30.

In one of the earlier types there will be noticed a single-cylinder engine, 11 × 15. This engine was rated at 20 HP. at 220 r. p. m. and at a piston speed of 550 ft. About 22 HP. was all that could be got out of it, and the rate of fuel consumption was high—about one and a fifth pints per HP. per hr. You who have followed the progress made in internal combustion engines for the past few years will readily agree that the piston speed of this engine is enough to condemn it; but let us call your attention to the fact that 15 years ago that piston speed was considered extremely good practice, and even to-day some of the best engineers in the employ of the Government are sending out specifications for bids on internal combustion engines wherein they specify that the piston speed must not exceed 700 ft. per min.

For the purpose of comparing the work of the short-stroke engine with the work of the long-stroke engine, we call your attention to the table of the long-stroke engines we have given. You will notice in this table a 10 × 18. This engine was designed to take the place of the 11 × 15 of the earlier type. It weighed about 1,500 lbs. less, and was built for 25 HP. at a speed of 265 r. p. m., or a piston speed of 795 ft. per min. Thorough test showed this engine would develop 40 HP. on a smaller consumption of fuel than that on which the 11 × 15 would develop 22 HP.; also that the efficiency of this engine continued to increase as the piston speed increased up to 850 ft. per min., at which speed it proved to develop a horsepower on the least amount of fuel. It is interesting to note that when the bore of the cylinder was reduced the crank-shaft and all other parts were correspondingly reduced in size, with a decrease in weight of about 1,500 lbs. After ten years' service under all conditions it has shown clearly that it is much more durable and costs less for repairs than the shorter-stroke engine.

We might go through the entire list and make a comparison of what was accomplished with the long and short-stroke types, but it is enough to state here that the results were all in line with the case we have just cited. It was shown that the piston speed must be much higher in some engines than in others in order to get the best results, showing conclusively that trying to hold to a given piston speed regardless of whether or not the engine is of short or long stroke, large or small bore, is all wrong.

Advantages of Long-Stroke.

Briefly, I would say that the advantages of a long-stroke engine over a short-stroke are:

1. Much lighter weight for a given horsepower.
2. Longer life.
3. More economical use of fuel.
4. Less radiating surface required for cooling.
5. Smoother running qualities and less noise.

WEIGHT AND ROTATIVE SPEED.—It seems to be the prevailing opinion that the longer-stroke engine is of heavier design. Our entire experience has been exactly the opposite. For an illustration, take a 4 × 4 engine of modern construction. It is a bad design indeed, if any good designer cannot copy it, changing it to a 4 × 5½, making a motor of as long life at an increased weight of from 5 to 10%. In making the change, he will get an increase in power of from 25 to 35% at the same number of revolutions per min. He will not have increased the initial pressure on the piston head, the shock caused by the instantaneous expansion of the gases at the beginning of the stroke, or the pressure on the bearings. Hence there is no occasion for increasing the thickness of the piston head, cylinder walls or other parts.

The advocate of the short-stroke will at once reply that

*Abstract of a paper read before the January meeting of the Society of Automobile Engineers in New York City.
†Model Gas Engine Works, Peru, Ind.

he will simply increase the speed of his engine until he gets the same piston speed and will then get the same power. At first glance it seems that he is right from a theoretical standpoint. But such is not the case. Neither is he correct from a practical standpoint. In the first place, the greater the rotative speed, the more the power required to propel the engine itself. We must not lose sight of the indicated and actual horsepower and the fact that the power required to drive the engine itself must be considered as lost. It should be quite clear that it will require more power to turn the 4 × 4 engine a greater number of revolutions per minute to get the same piston speed as the 4 × 5½. Hence if there were no other advantage, this increased frictional loss would prevent the securing of the same power from the shorter-stroke engine.

There is a speed at which every engine will produce the most power for the amount of fuel consumed. It will be found that the actual pull in pounds will increase with the speed of the engine up to a given point, when the pull in pounds will begin to decrease. If the speed is increased beyond this point the engine will continue to develop more power, but not in proportion to the increase in speed; hence, at a greater fuel consumption. On the other hand, below the speed at which the pull in pounds is greatest, the horsepower is not only less, but the fuel consumption is greater per horsepower developed. If you test this out fully you will find that the highest point of efficiency is at a higher piston speed on a long-stroke than on a short-stroke motor.

LIFE OF ENGINE.—The long-stroke engine of a given horsepower has a smaller cylinder diameter, and as the initial pressure on the piston head is practically the same in both long or short-stroke construction if there is no difference in the diameter of the cylinders, it is clear that the actual pressure on the piston head in the engine of smaller diameter and longer stroke will be less than in that of larger diameter and shorter stroke. As a natural result, the shock caused by the quick expansion of the gases at the beginning of the stroke is less in the smaller diameter; hence the work on the bearings is not so severe. In the short-stroke engine, practically all parts, with the exception of the piston, must move faster. This, together with the number of reversals of direction of motion per unit of time, must necessarily mean more wear on bearings, valves, valve-stems and cams.

It is well understood that the intake valve does not require as much regrinding as the exhaust valve does, the heat of the escaping exhaust gases being responsible for the difference. If we can reduce the temperature of the burnt gases as they are permittd to escape through the exhaust valve (which is accomplished with the long-stroke motor) we thereby reduce the need for regrinding to that extent.

FUEL ECONOMY.—From a given quantity of fuel we get a certain number of heat units, the distribution of which we might divide under the following heads: A, frictional losses; B, loss by reason of heat carried off through the cylinder walls; C, loss through the exhaust; D, amount converted into power. Frictional loss has already been considered in discussing rotative speed, so we may proceed at once to the second item, radiation loss.

It has been stated, frequently by very able men, that the loss through radiation or through the cylinder walls of a short-stroke engine was less than in the long-stroke engine and that for this reason the former was more economical of fuel. In this opinion the author can in no way concur. This old argument is based upon the theory that the stroke being longer, more of the cylinder wall is exposed, and as a result there is more chance for the heat to be carried off through that part of the cylinder swept by the piston. If this were true, the loss would still be less than on the short-stroke engine with the larger bore, for the reason that the compression chamber on the larger bore leaves a greater exposure of wall surface. Again, this greater wall exposure in the compression chamber occurs when the compression is at the highest possible point, while with the long-stroke engine, that part of the cylinder wall swept by the piston by reason of the longer stroke is not exposed until the pressure has reached the lowest possible point. Hence the loss would not be so great even with an increased wall exposure in the longer stroke.

In order that we may properly understand this, we must get some idea of the capacity of the cylinder walls for absorbing and carrying off heat. Let us assume that we have a proper mixture of gas and air confined in the compression chamber of the cylinder of a properly constructed motor with all valves closed, no leaks of any kind, piston immovable, compression 60 to 70 lbs. and the charge ignited. Under these conditions, it will be seen that there can be no heat converted into work, no frictional loss and no loss by means of exhaust; in fact no escape of heat except through the cylinder walls.

Let us further assume that when this charge is ignited, it will immediately expand and create a pressure within compression chamber of from 300 to 350 lbs. per sq. in. If we were to ask the man who had not given this matter careful thought, or who had made no practical test of it, how long it would take under such conditions for a sufficient amount of this heat to be carried off through the cylinder walls to reduce the pressure within to 100 lbs., he would more than likely say from five to ten minutes. If we were to tell him that as a matter of fact it will take less than two seconds, he would either not believe it or would at once begin to realize what high piston speed means when it comes to a question of economy. It is thus seen that when we increase the piston speed, there is less time for the heat to be carried off through the cylinder walls, and as a result more of it is converted into work. When this is done by means of increasing the stroke, there is but little frictional increase and a clear gain in power, with less fuel consumption.

It follows that with the longer stroke the compression can be increased over that of the short-stroke engine, without any of the bad effects or disadvantages of too high compression. Increased compression is another step toward more economical operation.

EXHAUST LOSS.—It is evident that the further you expand the gases, the less heat will be carried off through the exhaust. Observation of the exhaust alone from a long and short-stroke engine, both properly constructed, should be sufficient to satisfy the mind that the exhaust gases can be permitted to escape under a lower pressure with the long-stroke engine. A properly-taken indicator card will show this clearly.

COOLING SURFACE.—The advantages here are covered almost completely by the remarks as to loss from radiation through the cylinder walls. If we have less loss through the cylinder walls, we require correspondingly less cooling surface, which means a saving in expense as well as a reduction in weight.

RUNNING QUALITIES.—Smoother running qualities and less noise are secured in the long-stroke engine because of the fact that the initial impulse is much less. The pressure on the piston head is the same whether the motor has a 4-in. stroke or 6-in. stroke, if the diameter and compression in both are the same. If we must use the larger bore, in order to secure the same power, we must expect the natural results of a larger motor, or of a larger cylinder diameter with the same stroke. The noise must necessarily be increased in an engine running at a greater number of revolutions, because of the increased speed of opening and closing valves, and the more rapid movement of the other parts of the engine.

Again, it is a well-known fact that with the long-stroke motor you secure better mixing and vaporizing of the charge. You can throttle the motor down lower, so that it will pull much more steadily, quietly and smoothly on hills or on slow speed under heavy load. It is not difficult to see that the further the gases are expanded, the less noise will be created by the escape of the exhaust gases; likewise, that exhaust valves will open against less pressure.

Ratio of Stroke to Bore.

Many other reasons might be advanced in favor of the long stroke. The author has tried to touch upon what he considers the most important. The question of the best proportion of the stroke to the bore has not been taken up for the simple reason that so much depends on the work for which the engine is to be used. What may be ideal in one case may be all wrong in another. Where you have a given number of revolutions per minute, as in stationary work, the better practice is to use the longest stroke possible consistent with a smooth running engine. Where you must have variable speed, the better practice in our opinion is to have the stroke such that the piston speed will be at a point showing the greatest efficiency when running at the number of revolutions per minute at which the engine will be more generally used.

Generally speaking, for engines used for work requiring a variable speed, the smaller the motor, the greater the stroke can be in proportion to the bore.

Carrying the long stroke to the extreme or to the point of what is sometimes called freak construction will only do injury to its progress, but we have had this to contend with in connection with every new idea since the creation of man and must expect to see it carried to a point where stroke is out of all proportion to the bore from the standpoint of good construction.

Commercial Vehicles.

In speaking of the proper proportion of the bore to the stroke, depending on the work of the motor, the author desires to make it clear that he believes the advantages of the long-stroke engine are much more essential to the construction of good commercial vehicles than pleasure vehicles, because of the wide speed variation in pleasure vehicles. With the truck or commercial vehicle, the conditions are different. The governor is now being used extensively on motor trucks for limiting the speed, and a fourth speed is being used in the transmission, for increasing the speed of the car when running light. Hence the motor can be operated more nearly at the piston speed at which it will give the most economical results.

Regardless of how far we may go in the future in the increase of the stroke of engines used for pleasure vehicles, we are firmly convinced that the engine with the bore equal or nearly equal to the stroke will very soon be a thing of the past for the truck or commercial car.

Take, for illustration, the 4 × 4 engine to w[illegible] we have formerly referred. In order to get the best re[illegible] from a standpoint of fuel consumption per horsepow[illegible]veloped, it would be necessary to run it at a speed of [illegible]mething like 1,400 to 1,500 r. p. m. It would be far b[illegible]r prac-tice to increase the stroke so that the desired p[illegible] speed could be obtained at something like 1,000 r. [illegible]., and by so doing to operate a greater part of the [illegible] at the speed where the most power will be produ[illegible]r the amount of fuel consumed, with the further [illegible]ration of less wear and tear on the engine.

It is difficult to pick up a present-day tra[illegible]ournal commenting on the long stroke of Europea[illegible]motors, which does not attribute the development of [illegible] long stroke motor on the Continent to the tax cond[illegible]s. We agree that the tax question may have had so[illegible]hing to do with the hastening of its development, but [illegible]us not deceive ourselves; it is only a question of tim[illegible]hen we must all admit that the progress of the long-st[illegible] motor is due almost entirely to its manifest advantag[illegible]ver the short-stroke type.

Damage to Telephone and Telegraph Poles by Wood-Boring Insects.*

Special investigations, in cooperation with telephone and telegraph companies, have shown serio[illegible] and extensive damage in certain localities to standi[illegible] poles by wood-boring insects. The principal injury consists in large mines in the wood near the line of contact with the ground. These irregular mines run both transversely and longitudinally through the heartwood and are often as much as 7 ins. long. They occur in the outer layers of the wood from 2 to 3 ft. below ground to 1 or 2 ft. above, the greatest damage being just below and just above the surface of the earth. The mines are often very close together and completely honeycomb the wood in a zone from 3 to 4 ins. in from the exterior of the pole. This weakens the poles so that they break off close to the ground, especially in time of storm.

Serious damage has been found in as high as 10 or 15% of the chestnut poles which have been set in the ground from ten to twelve years in North Carolina, Virginia, West Virginia, Maryland and the District of Columbia. It has recently been determined that a considerable portion of the cedar (arborvitae) telephone poles in part of a line in Illinois have been seriously damaged.

The principal species of insect working the damage is the "chestnut telephone borer," or, as it is now more commonly called the "pole borer." This is an elongate, creamy-white, wrinkled, round-headed grub hatching from an egg deposited by an elongate, mahogany-brown, shiny, flattened, winged beetle about from 2.5 to 4/5-in. long. The eggs are deposited during from August to October in the outer layers of the wood near the ground. The young borers, on hatching, excavate shallow galleries in the sapwood and then penetrate the heartwood. As they proceed, the fine boring dust is closely packed behind them. This is a peculiar semi-digested dust quite characteristic of their work, and is of a reddish or yellow-brown color and has a clay-like consistency. The burrows eventually end in a broad chamber, entrance to which is plugged with fibers of wood. Here is the resting-place for the pupa which transforms into the beetle.

This insect attacks poles that are perfectly sound, but will work where the wood is decayed. It will not, however, work in wood that is wet-rotten or punky. It has not been determined just how soon the borers enter the poles after setting, but poles which have been in the ground for only two years have been found to contain young larvae in the outer layers.

Another very common injury is done to poles by white ants, or termites. In pole lines ten to twelve years old, serious damage has been found in as high as 15% of the poles, and their attacks have been found, more or less, in 75% of the poles. The damage is usually to the outer layers, which are moist, or where there is incipient decay. In a few cases the sound heartwood of these poles is often completely honey-combed at the base. The longitudinal weathering cracks in chestnut poles have often been widened by large black carpenter ants and smaller black ants, which has hastened decay.

Superficial treatment of poles with various preservatives has been found to be temporarily effective in keeping out wood-boring insects. If the work is not thoroughly done, the pole borer and other insects enter through the untreated portions, especially through weathering checks and knots. When the base is left untreated, insects, especially white ants, enter the pole from below ground to avoid the treated portions. Impregnating the poles with creosote by some particular process (such as the open-tank or pressure process) will keep out these insects. In the open-tank method only the area most subject to attack is treated (some 8 ft. of the butt), while in the cylinder process the entire pole needs to be impregnated.

*Brief abstract of Circular 134 of the U. S. Department of Agriculture, Bureau of Entomology, Washington, D. C.

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The Brooklyn Engineers' Club recently held a very successful exhibition of engineering materials, processes and models. The exhibition was held at the Club's house, 117 Remsen St., Brooklyn. It was open every evening for a week, and the attendance was very gratifying. There were 30 or more different exhibits, among them a number of recent inventions in engineering work, working models of machinery, large maps showing the proposed extensions of rapid transit subways with reference to Brooklyn, etc.

This is claimed to be the first exhibition of the sort ever held by an engineers' club in Greater New York. The American Institute of Electrical Engineers, however, has on a number of occasions held successful conversazioni at which exhibits of apparatus and inventions have been a prominent feature.

We think it worth while to call especial attention to this departure by the Brooklyn Engineers' Club, because it is a line of work which many engineering societies, we believe, might most profitably take up. There is, unfortunately, an old-time prejudice against an engineering society having anything to do with the exhibit of actual apparatus, or models, or tools, or machines. The idea is still tenaciously held that such exhibits are in some way derogatory to the dignity of a professional society. This prejudice exists in some of the national engineering societies merely as a time-honored tradition. In other societies it has imbedded itself in the organic law. The by-laws of the American Society of Mechanical Engineers, for example, admonish that society's Committee on Meetings that

> it shall prohibit the distribution or exhibition at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery.

This rule is rigidly adhered to, we regret to say. We believe there was once an enthusiastic young inventor with an ingenious piece of apparatus of much scientific interest who ventured to bring a model of his device to a summer meeting of the Society and place it in the headquarters where visiting members could see it. The device and the deviser were frowned upon by the Society dignitaries, and it never has happened again.

It seems to us that rules and traditions of this sort are positively harmful. From any broad point of view they are, in fact, absurd. If it is of professional interest to describe a machine in a paper, to illustrate it with drawings and photographs or with the aid of a stereopticon, then it surely is of professional interest to illustrate the construction of the machine by models or, where circumstances permit, by the machine itself.

This prejudice—for it is nothing else—against the exhibition of machines or models or apparatus in connection with professional societies, is of a piece with the prejudice against any paper offered for reading at a meeting or for publication in a society's transactions which is found to contain advertising. The fact is, of course, that everybody who writes papers for these societies is in one way or another seeking publicity. So long as this publicity is given in a straightforward, honorable, dignified manner, and so long as the paper deals with matter of real novelty and interest, there is no objection whatever to the so-called advertising. The true basis on which a paper offered to an engineering society should be judged is the basis that has been long in use in the selection of matter offered for publication in Engineering News. The question asked concerning every contribution offered to us is, what is its practical usefulness and interest to the working engineer?

The holding of exhibitions by engineering societies may well be judged on the same basis. Are such exhibitions useful and instructive? We believe progressive engineers will generally agree that there is a great deal to be learned in visiting such an exhibition if it be properly planned and conducted. Such organizations as the Master Car Builders' and Master Mechanics' associations contribute to the advancement of the industry quite as much by the annual exhibition of railway appliances held in connection with their annual conventions as by their formal meetings and proceedings.

We suggest, therefore, that the example of the Brooklyn Engineers' Club is one well worthy of imitation. If the engineering organization in a city will take up such a project in thoroughgoing fashion, organize an exhibition containing things of real interest and novelty, conduct it along high-class lines and open it to the general public, they can bring engineering and engineers into more prominent public notice and do more real good to their profession in the city than they can in the entire year's work of holding cut and dried meetings in the old-fashioned way.

Those of our readers who have to do with road construction and who know by experience the long and difficult and expensive operations involved in building a mile of "motor-proof" road will be interested to learn of a feat of road-building reported by the newspapers in Arkansas last month. We reprint the item as follows:

BUILD SEVEN MILES ROAD IN ONE DAY.

WYNNE TO LEVESQUE ROAD CONSTRUCTED IN 10 HOURS.

WYNNE, Ark., April 12.—The much talked of and long looked for road working day has passed and it has been demonstrated what can be accomplished by united effort and concerted action.

Last night a meeting was held here and all the preliminaries were arranged, men appointed to different squads, etc., and this morning by 5 o'clock the men were on their way to their respective stations, the work being divided into sections, ten in all, and each section had their foreman and the necessary tools, teams, etc., assigned to them.

The road, seven miles in length, began at the outskirts of the city on the Wynne to Levesque road. The first part of the road was in the hills and required a great deal of cuts and fills. Large galvanized pipes had been secured for the little runways, and these were put in and filled over, doing away with bridge work altogether. In the hills the most of the work was with scrapers, plows and graders, and the road was put in fine shape.

After about four miles of this kind of work came the bottom lands where trees had to be cut, briars encountered and ditches to fill. The bunch of men assigned to this duty worked faithfully and well, and accomplished a great deal. The heaviest part of the work on the entire road was a bridge to be constructed entirely out of timbers 65 ft. in length. This bridge was practically completed in one day under the foremanship of O. C. Beamon, a bridge builder, and some 20 men. There remains one span yet to go in which was left on account of material not arriving. Several miles of fencing were built and from Levesque to the bay A. H. Hamett, with a force of men and teams and several graders, constructed a magnificent road that will stand the test.

The entire road was not completed today, however, but such a start was made that the overseers along the route can easily in a short while, with their regular hands, make one of the best roads in the State of Arkansas. The worst has been overcome. The bridge will be completed at once. This was such a success that we advise other communities to do likewise.

It is interesting to reflect that it is by methods not very dissimilar to those above described that a large part of our present highway system was originally located and built. In many cases, indeed, such pioneer work represents the very best that could be done under the circumstances and not seldom gave opportunity for the display of native ability and good judgment.

For the most part, however, the day for that sort of road construction has passed; and a State which counts such roads among its first class highways needs to lift itself out of the mud so that the wheels of progress can go round faster.

Forty years ago New England was the paradise of independent railway corporations. Within her borders there were at that time probably a hundred or more independent operating railway corporations, great and small. Many of these little railway lines had had a notable history. They were built in the early days of railway construction, when New England, with its large wealth and densely populated territory, cut a far more important figure in the nation than at the present time. Many of these railway lines were built as local enterprises, and those who owned their stock and who operated them had no idea but that their little, independent, isolated, local road was to continue its existence indefinitely.

Looking back now, however, it is evident that the condition which then existed could not long survive. The stress of competition compelled the formation of combinations and the economies possible through consolidation also operated to make the condition of independent lines unstable.

The last step in the consolidation of New England railways was concluded last month with the announcement on April 24 that the New York Central Co. had admitted the New York, New Haven & Hartford Co. to equal participation in its lease of the Boston & Albany R. R. The Rutland R. R. system, on the west side of Vermont, which has for years been part of the New York Central system, has also been included in the same arrangement. In this way, the New York, New Haven & Hartford Co. comes into control of the entire railway system of New England with the sole exception of the Grand Trunk's Central Vermont line and a few local roads of no strategic importance. None of these local roads are of any considerable length except the Bangor & Aroostook system in Northern Maine.

All this consolidation has taken place within the memory of men still young. The first step was the aggregation of the small independent roads into minor systems, which were, indeed, considered great in their day, such as the Old Colony system in southeastern Massachusetts and the Boston & Lowell system in northern Massachusetts and New Hampshire. The absorption of the old Colony system by the New York, New Haven & Hartford some 18 years ago was followed by the acquisition of various other railways in Connecticut and Massachusetts by the latter company until it came into control of practically all the territory in southern New England.

A little earlier the Boston & Maine secured equally complete control of everything in northern New England, with the exception of the Central Vermont line, of which the Grand Trunk had already secured possession as a New England outlet. Two years ago the New Haven Co.,

with the consent of the Massachusetts legislature, added the Boston & Maine system to its own.

While the Boston & Albany R. R., whose territory lies between these northern and southern systems, has been in friendly hands since its lease by the New York Central, it is undoubtedly in the public interest that the whole railway system of New England should be operated as a unit and the voice given to the New Haven Co. in connection with the Boston & Albany tends toward this end. With the broad state and federal control of railway operations now established, there need be no fear that the consolidation which has taken place can be made use of to seriously injure any public interest.

We have referred above to the one important exception to complete control of the New England railway system by the New Haven company. That exception is the Grand Trunk's Central Vermont line which extends from Montreal south across Vermont, Massachusetts and Connecticut to a terminus at New London, on Long Island Sound. By an arrangement concluded last week this company is to build a branch to Providence, R. I., and the Massachusetts legislature has adopted resolutions inviting the Grand Trunk to extend its lines to Boston.

While the distance to be covered would not be great, the expense of the right of way for an independent railway line, and adequate terminal facilities in Boston would be so great that the careful English capitalists who own the Grand Trunk are likely to weigh the prospect very carefully before proceeding. Assuming that one or both of these lines are built, however, their competition is not likely to be of great moment to the New Haven company. The Central Vermont line has not the gradients or the alinement to move a heavy traffic economically, nor is the volume of traffic likely to be obtained by it under even most favorable conditions likely to be such as to justify a heavy investment for its reconstruction.

It is always easy to make promises to reduce taxation before an election, but after getting into office the common experience is that it is difficult to keep the promises so freely made during the enthusiasm of a political campaign. This has recently been found true by the so-called "Progressive" party in the London County Council, and we should be greatly surprised if it is not found equally true in a number of American cities and states which witnessed political overturns last November.

For many years the London County Council, which since 1889 has administered the affairs of nearly 30 cities and boroughs comprising Greater London, was in control of men who believed most heartily in municipal ownership and in carrying on public work by day labor rather than by contract. Two years or so ago this party had to yield control to the opposition. These "Progressives" had promised that they would reduce the tax rate. According to our London contemporary, "The Local Government Officer and Contractor," the tax rate has actually gone up by 2¼d. in the £. Our contemporary says "the minority taunts the other party" with its failure to reduce the rate and "by way of adding insult to injury it is further alleged that but for a balance left when the party now in the minority was in power the increase in the rate would have been a penny more." The "Progressives" explain the increase in a way quite familiar this side of the water: that is, they claim that the increases have been due to educational and other expenses quite beyond local control.

There is, of course, no occasion for discussing the London situation further than to call attention to the fact stated in our opening sentence. It would seem, however, that the political parties would learn by experience to temper their claims for reduction of taxation in such a way as to afford them easy explanation when the tax rate goes up instead of down, as is almost always the case. It would also seem that the voters at large would finally regard these promises for reduced taxation as merely so much political humbug. But the facts are that politicians and voters both like to think that a change in government will result in reduction of taxation.

It ought to be realized by thinking people that with the many demands for public improvements and undertakings of one sort or another which seem to be unavoidable at the present day, or at least which the people are unwilling to do without, no material reduction in taxation is likely, no matter how thorough-going reforms are made in personnel or in methods of administration of our state and local governments. The greater likelihood is that both taxes and indebtedness will increase. The pertinent question is not how much tax rates or per capita indebtedness can be reduced, but how much more can be secured for the money expended.

So much has been written and published concerning the decline of American shipping that it will doubtless surprise most of our readers to learn that the actual tonnage of the United States merchant marine exceeds that of any other country in the world except Great Britain. The total shipping of the United States on June 30, 1910, included 25,740 vessels of 7,508,082 tons. It is pointed out by our contemporary, "International Marine Engineering," that this is a greater amount of shipping than the combined merchant fleets of the three greatest maritime nations of Continental Europe—Germany, France and Norway. It is true that the tonnage of American vessels engaged in foreign trade forms a comparatively small proportion of the whole, yet this amounted to 878,000 tons in the year ending June 30, 1909. The shipping on the Great Lakes was 2,782,000 tons, and on Western rivers 162,000 tons. The vessels in the Atlantic and Gulf trade were a little in excess of 3,500,000 tons, and in the Pacific trade 934,000,000 tons. The very large volume of our coast shipping and of the shipping on the Great Lakes, compared with the insignificant amount of shipping on inland rivers are worthy of note in connection with the proposal to create at enormous cost an inland waterway parallel to the Atlantic Coast. The promoters of that scheme ought to provide also a subsidy for the vessels which should use it to enable them to compete with craft using the present routes.

Financial Losses and Proposed Preliminary Treatment of Sewage at the Berlin Sewage Farms.

The extensive sewage farms of Berlin, Germany, have long been exhibited before the popular eye as notable examples of the profits which may be realized from the utilization of the fertilizing value of sewage. Within the past few years several well-meaning men, with more zeal than knowledge, have advocated pumping the sewage of New York City onto the sandy areas of Long Island as a means of preventing the pollution of the waters surrounding New York City, while at the same time bringing in a substantial revenue. Others, with equal zeal and even less knowledge, have proposed to turn some of the Jersey meadows into sewage farms, little understanding that the primary consideration for even the smallest measure of success in sewage farming is naturally-drained porous land rather than such water-soaked, close-grained soil as composes the Jersey meadows.

Even the poorest informed engineers know that sewage farming has many limitations, but only a comparatively few are aware of how many and serious these limitations are. The fact is that, after an experience of half a century with sewage farming, large numbers of municipalities in England and in other European countries are either abandoning their sewage farms or adopting some form of preliminary treatment in order to lessen the difficulties which arise in connection with broad irrigation. Some of these difficulties are due to increased volumes of sewage which have resulted from growth of population, so that the land has become overtaxed.

The obstacles in the way of secur[ing] further extensions of sewage farm areas mak[e] necessary to adopt some means of lessenin[g] the burden upon the existing areas through pa[rt]ial purification of the sewage before it is appl[ied] to the land. In addition to this, there is reas[on] to believe that many of these foreign mu[nici]palities are being convinced against their will [that] sewage farming results in serious econo[mic] loss instead of producing the profits which [have been] distorted or inadequate accounting, h[ave] been made to appear on the municipal balan[ce] sheets.

However all this may be, we learn fr[om] foreign exchanges* that Berlin has under con[sid]eration works for the preliminary treatment [of] sewage before it goes to its sewage farms. We also learn from the same source that, according to the annual report on the operations of the Berlin sewage farms for the year 1908, the farms as a whole were operated at a heavy loss during that year, and that they also show heavy losses from their inception to date.

As to the need for preliminary treatment of the Berlin sewage before its application to land, it is stated that this is considered advisable both to lessen clogging of the land by suspended matters and to make it possible to get rid of the sewage by other means than land treatment when the sewage farms or portions of them are in such conditions of crop and moisture as to make the application of sewage harmful rather than beneficial. We understand that the preliminary works will be biological in character, but their exact nature is not stated in the information before us.

It appears from the report just mentioned that at the close of the year 1908 Berlin had eight separate sewage farms, operated as one comprehensive system. The first of these farms was established in 1884 and the latest of the eight in 1907. The capital invested in the farms in 1908 was $15,393,000. Interest and depreciation charges on this investment for the year 1908 amounted to $790,000. To offset this large amount the excess revenue from the sewage farms over operating expenses for the year was only $58,400, thus leaving a net loss of $731,600 to be debited to the sewage farms of Berlin for the year. It also appears from the report that for the whole 24 years since Berlin began sewage farming the net operating profits (capital charges not considered) were $720,000. This, it will be seen, is considerably less than the capital charges for 1908 alone, but it should, of course, be noted that the capital charges of the earlier years were much less than those for 1908.

We present the foregoing brief review, not because any experienced engineer would for a moment think of recommending the establishment of sewage farms in the United States, unless in the arid West, but because any engineer who has to do with sewage-disposal problems is likely at any time to be confronted with assertions that the only proper scheme to adopt is one which involves sewage farming.

We have often expressed the idea that in those parts of the United States where water is at a premium for irrigation purposes sewage farming might be conducted with profit. The sewage of a comparatively few cities in the Far West is used in this way, but rarely, so far as we know, in a thoroughgoing, systematic manner. In most cases where city sewage is used for irrigation in the United States, it is not applied to municipally-owned farms, but is merely turned over in bulk to companies engaged in selling water for irrigation or else to farmers.

The one notable exception is the sewage farm of Pasadena, Cal., established a number of years ago. Large financial profits have been claimed for this farm, but we have never yet seen an adequate financial statement of receipts and expenses. A few meager figures are given each year in the report of the city auditor, but even these figures are not exhibited in balance-sheet form, and they fail to make any allowance whatever for capital charges. It is argued we believe, that no allowance for capital charges need be made, since the appreciation in value of the land used for sewage farming much more than

*"Gesundheit," Dec. 3, 1910; "La Technique Sanitaire," February, 1911.

takes care of capital charges. If so, this is the result of investment in land rather than of ownership and operation of a sewage farm, and in any event it should be shown as an inventory item or in a profit-and-loss account rather than in a statement of yearly operating results. The facts are, however, that no definite figures for appreciation in value appear in the accounts of the city.

Finally, we recommend the experience of Berlin and other European cities with sewage farming, as well as the comparative lack of American experience, to the attention of the State Department of Health of Oklahoma and some of the other officials of that state, who, as we understand, have recently been trying to secure legislation which would compel every municipality in Oklahoma which has a sewerage system to establish a sewage farm.

LETTERS TO THE EDITOR.

Another Plumb-Bob Hitch.

Sir: Referring to the article on the tying of a plumb bob string in your issue for March 2, 1911, permit me to suggest a much simpler method for preventing the string from slipping, yet permitting of the tying of a simple slip knot. The method I suggest is one used for many years by me and therefore tried and found satisfactory.

In the illustration accompanying that letter the string was shown as passing through the hook. My method is to wind the string once around the hook. When this is done the string cannot slip as long as there is any tension on it caused by the weight of the plumb bob. The slip knot may loosen and still the bob will hold. To change the position of the plumb bob it is only necessary to lift it and relieve the tension on the string in the hook.

Ernest McCullough.

1431 Monadnock Block, Chicago, Ill., March 4, 1911.

An Old Plumb-Bob String Catch in a New Form.

Sir: I note from your issue of March 2, 1911, that as our planetary system flies on its path, and the sun, moon, earth and asteroids travel their circled orbs, so the plumb bob question has completed its cycle and is again up for discussion.

A "New" Plumb Bob String Holder.

It is with a diffidence peculiar to our profession that I submit, with becoming modesty, the enclosed device, which I may say will settle the matter for all time and—for any engineer who chooses to adopt it—will render unnecessary a post-graduate course in how to string a plumb bob.

Having doped it out some ten years ago and used it continually since, it is possible to enumerate its advantages as:

Not patented and costs nothing.

Made by any one almost as quickly as tying a knot.

No knots for cold, numb fingers to tie in the field.

No knots and loose ends to snarl up.

Holds its position under any working strain.

Adjusted either way with one hand and stays put.

Saves time.

Minimum of wind effect.

Sounds good, doesn't it?

Joseph Ditto,
Assistant Engineer, Dept. of Public Works.

Buffalo, N. Y., March 7, 1911.

[There is a saying that "there is nothing new under the sun"—a point which our correspondent has brought out in his introduction. As for his device, we can state positively that the same identical thing has been fashioned in bone, vulcanite and wood for at least eleven years, which appears to be about the period of the plumb bob question in its orbit.

It is possible that some of our readers who are curiously inclined may be induced to try this "new" device, and to their judgment we leave the decision of the best material to be employed. —Ed.]

Fire Dangers in Cinder Fill Railway Embankments.

Sir: It is a common practice among railroads in this vicinity to construct embankments with cinders obtained from power-houses in which automatic stokers are used. The cinders are elevated to bins, which have undercut gates, and are of about two cars capacity. The bins are high enough to allow a gondola car to be placed underneath and filled by opening the undercut gate. Then the cinders are transported to the proposed new track and dumped, the fill being raised to grade by jacking up the track and placing the cinders underneath.

This is an economical method of embankment building, as the cinders which accumulate at the power-house are disposed of at the cost of elevating them into and discharging the bin, and much of the railroad embankments and many of the freight yards in this vicinity are made in this manner.

For low fills, say of 4 or 5 ft. in height, cinders make an admirable roadbed, being resilient under traffic, packing tight, and being inherently well drained. They should be used with caution in fills 8 ft. or more in height, for as the usual run of cinders is from 25 to 50% unburned coal, when packed by heavy service spontaneous combustion often takes place with consequent dangerous results. Cinder fills have been known to burn for years, necessitating much and expensive maintenance work.

Recently the writer had occasion to witness the partial destruction of a cinder fill roadbed. This particular fill is on the average 10 ft. deep and about three-fourths of a mile long. Before reaching the section which was being destroyed, a high degree of heat was felt emanating from the embankment. This heat was intense enough to be uncomfortable to the feet when walking over the affected region. In the zone of failure were deep cracks from which smoke issued and all of the ties had been destroyed. The embankment had settled considerably by reason of the reduction in volume, due to the consumption of the unburned coal by spontaneous combustion.

It was noticed that the railroad company had raked out of the fill a large quantity of cinders; had treated the top of the embankment with wet clay, which was thoroughly baked and made an effective oven, and had renewed the ties. This wet clay treatment did not reduce nor check the combustion but, on the contrary, intensified it.

It is the writer's opinion that burning cinder embankments can best be treated locally by the following method: As soon as a cinder fill is discovered to be burning, the limits of the combustion should be determined, then a three-pile bent driven about 5 ft. beyond the limits as determined. Then cut the fill at the bents, taking out about 5 lin. ft. of the embankment in front of the bents toward the burning section; then fill the cuts with dry clay and compact thoroughly. The combustion will then be confined between the limits of the clay end walls. As the embankment settles, maintain the track to grade by filling with sand.

The bents need only be strong enough to sustain trains while making the cuts. Dump boards should be placed behind the bents so that the fill cannot seek its natural slope.

This method will confine the destruction of the embankment to the limits selected and will prevent the spread of the combustion to the remainder of the embankment, which may not have a high enough percentage of unburned coal mixed with the cinders to ignite by spontaneous combustion, whereas, if the combustion were not confined, it would spread throughout the entire fill by encroachment.

Julius M. Bischoff,
Assoc. M. Am. Soc. C. E.

210 Union Station, St. Louis, Mo., March 27, 1911.

Weight and Price of Steel Ties.

Sir: I notice an article in your issue of March 30, 1911 (p. 380), which is descriptive of a new steel tie for electric railways. The estimated weight of the steel is given as 138.25 lbs., making a total cost of $1.34 per tie, plus extra for fastenings. In brackets, the pound price is given as 2 cts. per lb. It seems to me that some of the figures in the article must be in error, as I understand that the tie complete, with concrete, would cost from $3 to $3.50 each. If the tie costs, as stated in the article, about 2 cts. per lb., a cost of $2.76 per tie instead of $1.76 would be nearer right.

E. C. Anderson.

Buffalo, N. Y., April 17, 1911.

[The above enquiry was referred to the makers of the tie in question, whose reply is given below.—Ed.]

Sir: Your article describes our standard "Day" I-beam steel tie correctly. Further along in the article our channel tie (some of which have been installed here in Cleveland) is described, but the twin tie idea seems to have been confounded. We are offering channel ties for street car traffic only. We give herewith the exact weight of each tie. The "Day" standard twin steel tie for interurban and heavier traffic weighs as follows:

	Lbs.	Lbs.
12 ft. of 5-in. I-beam	9.75	117.00
10 ft. of angles	1.8	18.00
5 ft. of plate 12 × 30 × 5/16-in.	12.75	63.75
		198.75

This tie when fabricated weighs about 188 lbs., the weight being made less by punching the plate for the fasteners.

The channel tie weighs as follows:

	Lbs.	Lbs.
12 ft. of 5-in. channel	6.5	78.00
5 ft. of ¼-in. plate	10.2	51.00
10 ft. of angles	1.8	18.00
Total weight		147.00

The channel tie when fabricated weighs about 138 lbs. The price mentioned is correct; 2 cts. per lb. (f. o. b. Pittsburg). Our tie being a twin proposition, the weight and price should be divided by two for the purpose of comparison.

The International Steel Tie Co.
J. C. Madigan, Secretary.

Cleveland, Ohio, April 22, 1911.

More Concerning Examinations.

Sir: I have been entertained with the "spasms" in the legislatures of the various states for licensing engineers. In every case an examination is provided for before license will issue, except that the applicant may obtain a license on his record under varying conditions. The utter futility of any oral examination must be apparent to any one having experience. When my friend, J. F. Stevens, was Chief Engineer of the Panama Canal, he sent a requisition to Washington for 50 track foremen. I suppose all the applicants were put through about the same examination that applicants for state licenses as engineers will have to take. Out of the 50 he got only four that knew anything about track work. He then sent another call for fifty track foremen with the significant addenda: "Prime requisite, not to be able to read or write." This time he got track men.

It is fair to suppose that the examinations for licensing engineers will be made on substantially the same basis as the examinations for positions in say the U. S. Reclamation Service. If they are, the technical graduates just out of school will get the jobs and the licenses.

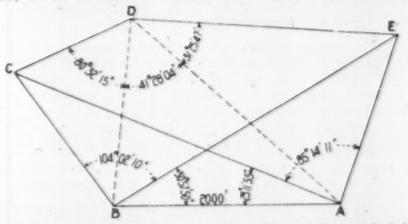
A few years ago I saw a set of examination questions of this sort and went over them with a friend who was then as now the Chief Engineer of one of the largest engineering works in the United States, with over 30 years' experience in engineering and construction. Between us we could not answer 30% of the questions without looking them up; but I am satisfied that a "Kid" graduate could have answered 90%.

E. T. Abbott.

Pokegama, Ore., April 20, 1911.

A New York State Civil Service Examination Problem.

Sir: The accompanying problem was part of a recent examination for a civil service position in New York State. The approximate time allowed for the computation, based on the total amount of work, was one hour.



A Problem in Trigonometry: To Find CD and DE in About One Hour's Time.

The problem has been solved by several methods each requiring some two or three hours' time.

Those who worked on the examination would be glad to know of some method by which the solution can be accomplished in about one hour and if you will put it before your readers we will appreciate it.

C. E. Harris, Asst. Engr.

202 Elk St., Syracuse, N. Y., April 5, 1911.

Notes and Queries.

Referring to the illustrations of steel scrapings ground off by the brakes on a steep railway grade, shown on p. 490 of our issue of April 20, Mr. Samuel T. Wagner, of Philadelphia, calls attention to similar illustrations of scrapings from locomotive tires, shown on p. 471 of the "Transactions of the American Society of Civil Engineers," Vol. 53, 1904, in Mr. Wagner's paper on the creeping of rails.

The Centering for the 281 ft. Concrete Arch of the Monroe St. Bridge, Spokane, Wash.

By P. F. KENNEDY.*

A general, descriptive article on the Monroe St. Bridge at Spokane, Washington, was printed in Engineering News, Sept. 2, 1909, p. 241. In the construction the most interesting problem has been the centering of the main or river arch, which has a clear span of 281 ft. with a rise of intrados of 114 ft. This arch is of the twin rib type. The ribs are 16 ft. wide by 6 ft. 9 ins. deep at crown and are 36 ft. apart, center to center. They flare toward the haunches, at which point their width is 19 ft. 9 ins.

Monroe St. runs north and south and the Spokane River is crossed by it at the foot of the last of a series of falls, the total drop in which approximates 135 ft. In the course of the ages a basin has been formed on the line of Monroe St., in which the water varies in depth from 50 ft. on the east property line to 30 ft. on the west property line. The low water flow of the river is 2,000 cu. ft., the high water flow 40,000 cu. ft. per sec. During the period of high water, the stream is very swift and turbulent. Just above the falls, there are situated several lumber mills and the breaking of a log boom would precipitate an immense number of logs over the falls.

The power plant building of the Washington Water Power Co. abuts on the east property line of Monroe St. and extends north from the south pier of the river span to the south border of the deep basin that has been described. The tail-races of the power plant traverse the line of the bridge. These several circumstances eliminated from consideration not only the use of falsework supported on bents in the river, but also the use of falsework which would require many temporary river bents for its erection.

On the other hand, the existence of a steel bridge on the line of Monroe St. offered a means of erecting falsework by suspension therefrom. This steel bridge was of the cantilever type; the anchor spans 189 ft. long, the cantilever and suspended span crossing the river 277 ft. long. By placing one pier upon a rock shelf rising between two of the power plant tail-races, and another pier upon a similar shelf on the north edge of the deep water basin, it was possible to obtain a span of 192 ft. for falsework symmetrically located with respect to the 281 ft. concrete arch. In the 44.5 ft. between such falsework piers and the piers of the concrete arch, a simple system of vertical post falsework could readily be constructed. The span of 192 ft. was therefore chosen for the center falsework.

After comparison of arch and truss spans for falsework, an arch was determined upon. The large steel bottom chords required in a truss by the heavy load of the concrete arch, made a combination arch, in which the heavily stressed members were all in compression, much cheaper. A combination arch was therefore designed, consisting of seven timber ribs, spaced 3 ft. apart on centers. A wider base was not given to the structure because of the location of the power plant upon the east property line of the street. Wind pressure was to be taken care of by guy cables in addition to the bracing.

Construction on the falsework arch was begun late in June, 1910. Cables suspended from the steel bridge supplied the means of erection. It was possible to erect the four western and the two easterly ribs without any interference with the steel structure. The third rib from the east, however, came directly in line with the easterly chord of the steel bridge and interfered in its upper four panels. Consequently, after the six ribs were completed and the seventh brought up to the point of interference, really active operations were suspended until the steel could be removed. On account of the fact that the uncompleted rib was kept blocked up in order to ensure a ready adjustment upon meeting at the crown, it was not feasible to put on the final bracing. The ribs were all tied together with temporary braces and there were 22 guys, up and down stream upon the structure.

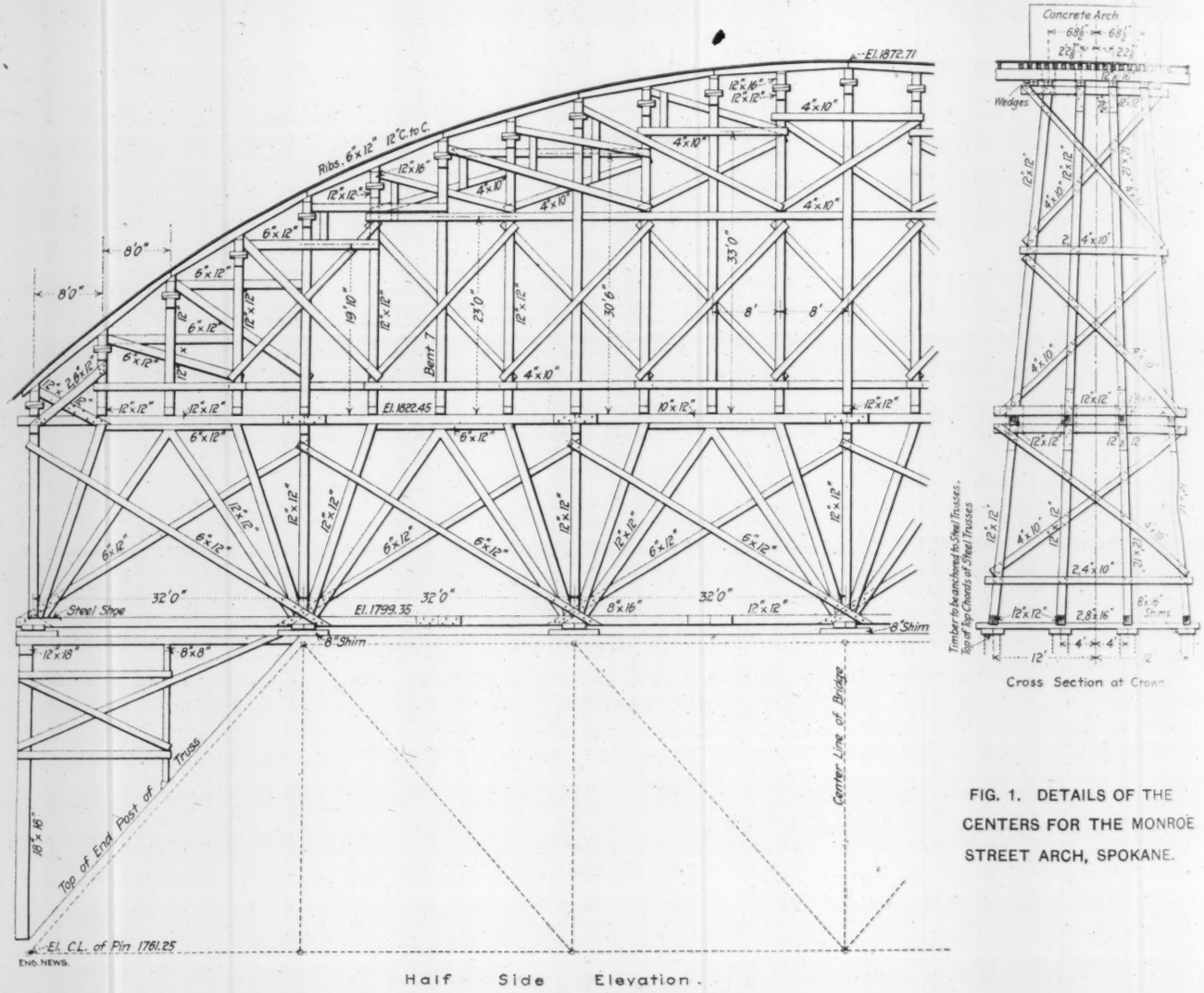


FIG. 1. DETAILS OF THE CENTERS FOR THE MONROE STREET ARCH, SPOKANE.

The timber arch was cut free from the steel July 13 and the work of removing steel begun. On July 20 the last piece of interfering steel was removed. With the resumption of work after the noon-hour of the following day, July 21, the clear weather of the morning continued, with the wind blowing 16 to 20 mi. per hr. from the southeast. About 1.40 p. m. there were evidences of a storm gathering in the west. According to the local weather reports, the first thunder clap came at 1.45 p. m. and at 1.46 p. m. the wind changed from 20 mi. per hr. S. E., to 42 mi. per hr. S. W. There followed a brief wind squall accompanied by rain. During this storm the falsework arch collapsed.

The weather bureau is located about one-third of a mile southeast of the river basin. The river gorge at the bridge site runs from southwest to northeast and in all likelihood, the storm fol-

*Engineer in Charge, Monroe St. Bridge, Spokane, Wash.

lowing the ravine caused a higher wind than on top of the building wherein the weather bureau is located.

From the testimony of eye witnesses the structure raised and collapsed, all members holding well together. Due to the excitement incident to such events and the brief space of time offered in which to make observations, the condition of the debris after the collapse offers perhaps a more noteworthy indication of what actually happened than the evidence of excited witnesses. The debris was piled high on the north shore and, of that portion which fell in the water, the most distant piece was scarcely over 50 ft. from the original line of the arch. There was no debris on the south pier and some timber which had been lying there was left undisturbed. Although positive conclusions are impossible, it seems reasonable to infer from the above circumstances that the sudden wind from the southwest, striking the structure at an angle of about 45°, lifted it clear of the south support and did not merely cause it to topple sideways as would have occurred had the arch not been guyed. An examination showed all the guy cable anchorages intact and none of the guys themselves broken.

In the collapse the power plant was slightly damaged and was out of service about thirty minutes.

The collapse of this timber arch presented anew the problem of centering. To re-erect the arch would necessitate the replacing of that portion of the old steel bridge already removed. Such a procedure was not only a step backward and therefore undesirable, but it was also deemed unwise because those portions of the removed steel members which were inaccessible in the erected structure, showed that the twenty years of over-stressing service had made their future use unsafe and the structure had in consequence already been condemned for re-erection as a highway bridge, without car service, farther down-stream, as was originally intended. It was then decided to adopt a system of centering composed of timber bents supported on four steel trusses of 192 ft. span, the four trusses to be used later in pairs to form part of the proposed bridge down-stream. The adopted system is shown in the accompanying drawing (Fig 2).

As shown there, it consists of a typical braced post timber falsework above Elev. 1822 of the arch, with a fan-shaped intermediate timber frame carrying the loads to the panel points of the four steel trusses, which in turn rest on the old concrete pedestals put in for the first centering. The sides of the arch are supported by additional timber framework resting on the ground, as shown in the half-tone in Fig. 2. The side forms are continuous for the whole width of the bridge but the main falsework is only under one of the arch ribs. When that rib is completed the cast-iron wedges near the soffit are struck and the entire falsework is to be moved over to the other rib, by means of rollers on the trusses resting in the concrete pedestal walls.

The work of dismantling the old steel bridge was continued after the accident and provision made in building the piers of the main spans for anchorages and toggles to allow of the erection of the steel trusses as cantilevers.

The steel for the trusses began to arrive in Spokane in the middle of February, erection was started March 2, 1911, and was completed in eleven working days of eight hours each, at a cost of $10 per ton.

All work is done by day labor, under the direct supervision of Mr. J. F. Greene, and the writer who in turn are under the direction of Mr. Morton Macartney, the City Engineer.

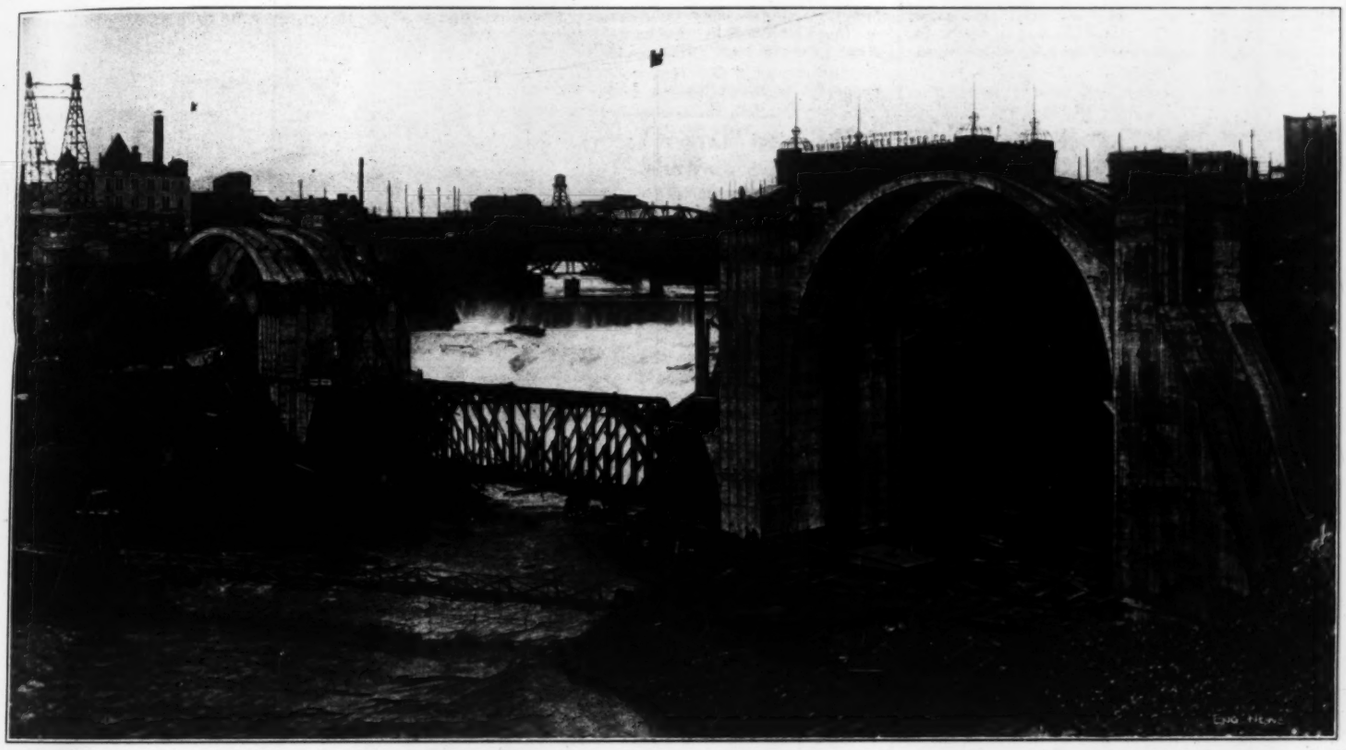


FIG. 2. VIEW OF MONROE STREET ARCH BRIDGE, SPOKANE, WASH., DURING CONSTRUCTION.
(Taken March 21, 1911. Showing four steel trusses and side forms in place.)

Excessive Rates for Gas and Electric Lighting Through the Operation of a Holding Corporation.

One of the most interesting decisions of the Massachusetts Gas & Electric Light Commission is that recently been made in the case of the North Adams Gas Light Co. It appears that this company has been supplying gas and electricity for some 20 years in North Adams, Adams and Williamstown, Mass. The price of gas up to Jan. 1, 1910, was $1.35 per 1,000 cu. ft. maximum, with discounts for large consumers. The price of electrical energy has been 13.5 cts. per KW.-hr., with lower rates for consumers using more than 15 KW.-hrs. a month. For motor service, current was furnished at 4 cts. per KW.-hr. maximum net price, with a minimum charge of $1 per HP. per month. Since Jan. 1, 1910, the rate for motor service has been 3 cts. per KW.-hr. At present a minimum charge of 50 cts. a month is imposed on gas consumers whose yearly average net bills are less than that. A minimum charge of $1 a month for electricity for lighting is imposed.

The Commission investigated the company's operation after receiving the complaints of several customers, in accordance with the law. It was found, by an examination of the books of the company, that the gross profits were not sufficient to pay the interest and dividend charges, even without allowance for depreciation, and that these were paid in part from a surplus fund. The cost of operation, for the gas and electricity services amounted to 85 and 88% of the gross incomes, respectively. The Commission believed these figures indicated that either the selling prices were too low or the operating costs were too high. As other concerns were able to supply gas and electricity at lower rates with a reasonable profit, there were grounds for believing that the costs were too high.

It was found that during the year 1909 practically all of the stock of the North Adams Gas Light Co. was secured by the so-called Massachusetts Lighting Cos., an unincorporated association controlling 16 other gas and electric companies in the state, and by the Light, Heat & Power Corporation, chartered under the laws of West Virginia.

This last company was chartered to manufacture, sell and purchase machinery and appliances, to build, equip, lease and sell water, light, power and heating plants and to furnish machinery and appliances for maintaining and operating these plants. It was found that the officers were identical with those of the North Adams Gas Light Co., and that nearly all the gas company's operations, particularly as to construction and purchase of materials, are carried on by the Light, Heat & Power Corporation. No written contract was found for this relation which was secured through identical ownership and management.

An examination of the books of the Light, Heat & Power Corporation showed that it made a substantial profit on all the supplies sold to the North Adams Gas Light Co. This profit amounted to $27,000 in 1910, not including sums paid for engineering services.

The Board also found that the increased salaries of the executive officers of the gas company accounted for a very large increase in the operating cost of that company, although these

THE LARGEST LOCOMOTIVE IN THE WORLD— 2-10-10-2 AND 12-WHEELED TENDER.

officers held similar places in the Light, Heat & Power Corporation and received salaries from the latter. The Board expressed the opinion that the salaries paid these executive officers, by the Light, Heat & Power Corporation alone, were full compensation for their entire services with the allied corporations and that the total salaries apparently received by these officers from the several companies were much larger than the volume or character of the business would justify.

The numerous claims of the Light, Heat & Power Corporation against the Gas Co. kept the latter almost constantly in debt to the former and the immediate transfer of most of the operating income was made directly to the Light, Heat & Power Corporation so that the latter, in addition to its other profits, secured the interest and the average balance of debt.

The Commission finds finally that the public is misled as to the actual reasonable cost of carrying on the business, and so is directly contrary to the spirit and purpose of the law. It finds that the company is entitled to a reasonable profit above only reasonable costs and that reasonable profits presuppose and are based upon reasonable costs alone.

The Board has recommended (1) that from May 1, 1911, the net price of gas shall not exceed $1 per 1,000 cu. ft.; (2) that the net price for electric current shall not exceed 12.5 cts. per KW.-hr.; (3) that no minimum charge for gas shall be made unless the consumer uses less than 100 cu. ft. of gas in any one month, nor during any portion of 12 consecutive months if during such time the customer uses gas to the value of $7; (4) that when the minimum charge is imposed, it shall not exceed 50 cts. for any one month; (5) that no minimum charge for electric current for lighting shall be made for any one month unless the consumer uses less than 1 KW.-hr., and shall not be made during any portion of 12 consecutive months if the consumer uses current for lighting during that time to the value of $12; (6) that when the minimum charge for electric current is imposed, it shall not exceed $1 per month.

The Commission reviews the arguments for the justification of the dealings between the gas companies and the Light, Heat & Power Corporation. It finds that to some extent the claim may be successfully made that the Corporation can supply the operating companies with materials at a profit to itself and for a price less than what the individual concerns can secure in the open market. The Commission finds that in the North Adams case the actual charges are too great to be so justified.

The outstanding capital of the Massachusetts Lighting Companies (the voluntary association controlling these companies) amounts to more than $3,500,000 and is greatly in excess of the stocks and bonds which the operating companies can be authorized to issue. The Commission is of the opinion that when a unified management of a group of companies actually promotes economy in operation and ability to serve the public, such management is entitled to commendation and a liberal reward, but that it is not wise that the entire profit from operation should be taken from the owners. The Board is of the opinion that the rates named are sufficient to cover reasonable operating expenses, depreciation and a fair return on the value of the property employed for the public convenience.

The Latest "Largest Locomotive in the World."

At various times we have had occasion to chronicle the construction of locomotives which have held successively the record for being the "largest locomotive in the world." The latest engine to hold the record, and one which seems likely to hold it for some time, is a Mallet engine of the 2-10-10-2 class for handling 2,000-ton freight trains on long and severe grades. This class of engine was mentioned in the articles on Mallet locomotives in our issue of April 20, and one of them is shown in the accompanying cut. The total weight of the engine is about 616,000 lbs., with 550,000 lbs. on the driving wheels (55,000 lbs. per axle), while the loaded tender (on six-wheel trucks) increases the total weight to 850,000 lbs. In Table I. are given the weights of some preceding locomotives in comparison with the above, and it will be seen that in load per driving wheel the new engines are exceeded by three earlier engines. The detailed dimensions are given in Table II.

The boiler is made in two sections, united by a rigid separable joint. Beyond the smokebox is a tubular section 9 ft. long forming the feed-water heater. Between this and the barrel proper is another tubular section forming the superheater; this is divided into two compartments, one for superheating the live steam, the other for reheating the high-pressure exhaust on its way to the low-pressure cylinders. The firebox is of the Jacobs-Shupert type, without staybolts. The firebox proper and outer shell are each composed of pressed-steel channels, bent to horseshoe shape and riveted together through the flanges; transverse stay-plates or diaphragms of horseshoe shape are fitted between the two sets of channels, and are perforated to permit of free circulation in the water legs and over the crown.

These engines are notable for the size of their tenders, which are mounted on six-wheel trucks and have a total weight of 234,000 lbs. (including water and oil fuel). They are practically identical with those of the 4-4-6-2 Mallet passenger engines described in our issue of April 20.

Three of these huge engines have been built at the Topeka shops of the Atchison, Topeka & Santa Fe Ry., by combining pairs of the 2-10-2 engines which have been a characteristic [illegible] on this road for some years. An order for ten new engines has been given to the Baldwin Locomotive Works.

TABLE I.—SOME OF THE "LARGEST ENGINES IN THE WORLD."

Railway.	Class.	Weight. Per driving wheel, lbs.	On drivers, lbs.	Engine, lbs.	Engine and tender, lbs.	In "Eng. News."
Union (Pittsburg)	2- 8-0	26,000	208,000	230,000	334,000	Oct. 27, 1898.
Ill. Central	4- 8-0	24,150	193,200	232,000	364,900	Oct. 26, 1899.
P., B. & L. E.	2- 8-0	28,125	225,000	250,300	391,400	June 21, 1900.
A., T. & S. F.	2-10-0	23,200	232,000	259,800	383,800	April 24, 1902.
A., T. & S. F.	2-10-2	23,458	234,580	287,240	453,000	Oct. 6, 1904. / June 2, 1910.
B. & O.	0- 6- 6-0	27,833	334,000	334,000	477,000	June 30, 1904.
So. Pacific	2- 8- 8-2	24,634	394,150	425,900	596,000	April 29, 1909.
Del. & Hud.	0- 8- 8-0	27,750	444,000	440,000	611,800	July 7, 1910.
A., T. & S. F.	2-10-10-2	27,500	550,000	616,000	850,000	(Present).

TABLE II.—DIMENSION OF 300-TON MALLET LOCOMOTIVES (2-10-10-2): ATCHISON, TOPEKA & SANTA FE RY.

RUNNING GEAR:
Driving wheels (20), diameter ..... 4 ft. 9 ins.
Truck wheels (4), diameter ..... 2 ft. 7½ ins.
Tender wheels (12), diameter ..... 2 ft. 10½ ins.
Driving wheel centers ..... Cast steel
Driving wheel tires ..... Shrunk on
Truck and tender wheels ..... Steel tires
Trucks ..... Swing center

WHEELBASE:
Journals, driving axles; main, 11 × 12; others, 10 × 12 ins.
Wheelbase, rigid (two groups), each ..... 19 ft. 9 ins.
Driving ..... 49 ft. 11 ins.
Total engine ..... 66 ft. 5 ins.
Tender ..... 32 ft. 6 ins.
Engine and tender ..... 108 ft. 1½ ins.
Truck axle to driving axle ..... 9 ft. 6 ins.
Length over engine and tender ..... 121 ft. 7 ins.
Blind tires ..... On main (middle) axle of each group

WEIGHT, IN WORKING ORDER (Estimated):
On driving wheels (20) ..... 550,000 lbs.
On front truck wheels (2) ..... 31,000 lbs.
On rear truck wheels (2) ..... 35,000 lbs.
Engine, total ..... 616,000 lbs.
Tender, empty, 105,000 lbs.; loaded ..... 234,000 lbs.
Engine and tender ..... 850,000 lbs.
Water in tender ..... 160,000 lbs.
Oil fuel in tender ..... 21,000 lbs.
Counterbalance ..... Conforms to M. M. Assoc. rules

CYLINDERS (4):
Cylinders, high-pressure (2) ..... 28 × 32 ins.
Cylinders, low-pressure (2) ..... 38 × 32 ins.
Ratio of area of h. p. to l. p. piston 1:1.84
Crosshead and guides: Laird for h.-press.; Alligator for low-press.
Connecting rods, length between centers ..... 8 ft. 4½ ins.
Side rods ..... Solid ends

VALVE GEAR:
Type ..... Walschaerts
Ports, steam; h. press., 28 × 1¾ ins.; l. press., 30 × 2 ins.
Ports, exhaust; h. press., 28 × 1¾ ins.; l. press., 30 × 2 ins.
Bridges, width ..... 2½ ins.
Eccentrics, throw; h. press., 15⅝ ins.; l. press. ..... 17 ins.
Piston valves; max. travel ..... 7 ins.
Inside lap; h. press., ¼-in. neg.; l. press., ¼-in. neg.
Outside lap; h. press., ¼-in.; l. press., 5/16-in.
Lead (full gear forward and backward); h. press., ¼-in.; l. press., 5/16-in.

BOILER: Wagon-top type.
Barrel, diameter at smallest ring ..... 6 ft. 6¾ ins.
Dome, diameter ..... 2 ft. 7½ ins.
Barrel plates ..... ⅞-in. and 15/16-in.
Smokebox tube plate ..... 9/16-in.
Horizontal and circum. seams ..... Double riveted
Joints ..... Butt
Rivets, diameter ..... 1¼ ins.
Height, rail to center line ..... 9 ft. 10 ins.
Smokebox, length (including extension) ..... 5 ft. 7 ins.
Smokebox arrangement, Does not conform to M. M. Assoc. rules
Injectors; two ..... Ohio non-lifting
Working steam pressure ..... 225 lbs.

FIREBOX: Jacobs-Shupert type (transverse channels).
Length and width inside ..... 12 ft. 5⅝ ins.; 6 ft. 6¾ ins.
Depth at back ..... 6 ft. 4½ ins.
Side and crown plates ..... 5/16-in.
Back plate ..... ⅜-in.
Firebox tube plate ..... 9/16-in.
Fire brick arch ..... Yes
Water spaces, width; front and back, 5 ins; sides, 5½ ins.

TUBES: Iron.
Number, 377; diameter, outside ..... 2¼ ins.
Thickness ..... No. 11 W. G.
Length over tube plates ..... 16 ft. 5 ins.

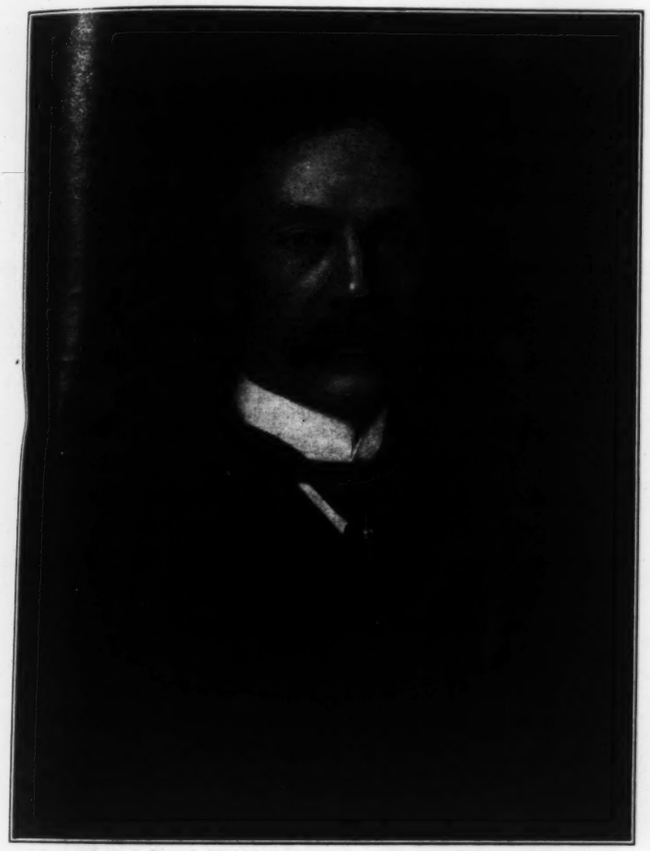
HEATING SURFACE AND GRATE AREA:
Heating surface; tubes (interior area) ..... 3,625.0 sq. ft.
Firebox ..... 294.5 sq. ft.
Feed-water heater tubes ..... 2,659.5 sq. ft.
Total ..... 6,579.0 sq. ft.
Superheating surface ..... 2,328.0 sq. ft.
Grate area ..... 81.9 sq. ft.

MISCELLANEOUS:
Exhaust nozzle, single; diameter ..... 6 ins.
Smokestack, diameter at choke ..... 17¾ ins.
Height above smokebox ..... 5 ft. 8 ins.
Height above rail ..... 15 ft. 6 ins.
Capacity of water tank on tender ..... 12,000 gals.
Capacity of oil fuel tank on tender ..... 4,000 gals.
Brake equipment ..... Westinghouse-American
Total tractive force (effec. press. equal to 85% of boiler press.) 111,600

Alexander E. Brown.

Alexander E. Brown, M. Am. Soc. M. E., President of the Brown Hoisting Machinery Co., of Cleveland, Ohio, died Wednesday afternoon at his residence in Cleveland, 2626 Euclid Ave., as a result of a stroke of apoplexy from which he suffered several weeks ago, following a similar attack three years ago.

Mr. Brown was a member of one of the pioneer iron and steel families of Cleveland. He was an eminent mechanical and civil engineer, was one of the men who perfected the Brush electric light, and was the original promoter of trade schools in Cleveland. He was an inventor of great genius, and machines originated by him are now used in all parts of the civilized world.



Alex. E. Brown

Alexander E. Brown was one of three sons of the late Fayette Brown, whose father, Ephraim Brown, came to Ohio in the early days, and with Thomas Howe purchased a tract of land which is now the site of the town of North Bloomfield, where Ephraim Brown lived until his death in 1845.

After the death of his father, Fayette Brown engaged in the dry goods business with a brother in Pittsburg. In 1851 he came to Cleveland, and entered a banking firm, but a few years later he became manager of the Jackson Iron Co., and continued in that position for 25 years. He was a prominent factor in the development of the iron business in Cleveland.

Alexander E. Brown was born in Cleveland May 14, 1852, and was educated at the Sterling Ave. grammar school and the old Central High School. He took a special course in civil engineering at the Brooklyn Polytechnic Institute, graduating in 1872.

Immediately following his graduation Mr. Brown joined the United States Geological Survey under Dr. F. P. Haven. Until November of 1872 he was engaged in the exploration and location of the Yellowstone National Park.

During the next two years he served as chief engineer of the Massillon Iron Bridge Co., of Massillon, Ohio, where he obtained his first real experience in the iron business.

From 1875 to 1878 he was engaged in bridge and building construction as engineer, designer and contractor. He later acted as superintendent at iron mines in the Lake Superior iron region and gained experience also in blast furnace work. In 1875 he invented and patented new machines and processes for annealing malleable iron castings, which are said to be still in use by the National Malleable Castings Co. in its plants in Cleveland and other cities.

In 1878 Mr. Brown became mechanical engineer for the Brush Electric Co., which was then known as the Cleveland Electric & Supply Co. He developed while with this concern the process and method of manufacturing light carbons. Still later he worked with Charles F. Brush in developing and placing on the market the Brush arc-lighting system.

It was in 1879, at the age of 27, Mr. Brown took up the problem of the rapid and economical unloading and handling of iron ore from boats. A year later he took out patents on the Brown Hoisting and Conveying Machines erected on the docks of the N. Y., P. & O. Ry. Co., now part of the Erie system. Then he organized the Brown Hoisting & Conveying Machine Co. for the manufacture of his machines, with his father, Fayette Brown, as President. Alex. E. Brown was the Vice-President and General Manager and active head of the company and has been its President since his father's death. For the past 30 years Mr. Brown spent most of his time designing and manufacturing machinery for the handling of different materials. He had taken out several hundred patents on his various inventions.

Mr. Brown took an active interest in the development of trade schools in Cleveland. He was one of the directors of the Training School Co., which was organized in 1885 to open a carpenter shop for boys in a building on East Prospect St., near the Pennsylvania R. R. tracks. This was opened in February, 1886, and pupils were admitted free for a course extending over three years. From this beginning the trade and manual training schools in Cleveland have increased to their present popularity.

Mr. Brown was a member of the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the Civil Engineers' Club, the Electrical Engineers' Club, the Union Club and the Country Club of Cleveland, the Engineers' Club of New York and the Chamber of Commerce of Cleveland.

In 1879 Mr. Brown married Carrie M. Barnett, daughter of Gen. Jas. Barnett, of Cleveland. The children by this marriage, Alexander C. Brown and Florence Cornelia Brown, with their mother, survive.

A LOCOMOTIVE BOILER EXPLODED April 27 on the Baltimore & Ohio R. R. just as the engine emerged from a tunnel between Silver Run and Petroleum, W. Va. The engineer was fatally injured and several other persons, none of whom were passengers, were less seriously hurt.

A SUGAR-DUST EXPLOSION is reported to have caused the fire of April 28 which destroyed the interior of the Arbuckle Bros. sugar refinery near the East River at Jay and John Sts., Brooklyn, N. Y. The loss is estimated at $400,000.

A FIRE AT THE CAR AND FOUNDRY PLANT of the Canadian Car & Foundry Co., at Amherst, N. S., April 27, destroyed the blacksmith and machine shops and the iron foundry, with a loss of about $150,000. The fire started in the blacksmith shop. Reports state that the rolling mills, malleable iron, axle and other shops which were not damaged will be kept in operation.

AN EXCURSION TRAIN WAS DERAILED April 29 on the Belvidere division of the Pennsylvania R. R., near Martin's Creek, N. J., causing the death of eleven persons and the injury of some 30 others, two of whom are not expected to recover. The train was being operated by the Delaware, Lackawanna & Western R. R. for the school-teachers' excursion from Utica, N. Y., to Washington, D. C. The accident took place on a sharp curve at a point where the track was being raised. Four of the five passenger coaches in the train rolled over into the deep ditch and were completely destroyed by a fire which was spread very quickly, according to reports, by the gas from the car-lighting tanks. It is said that a number of these cars were lit by acetylene.

SUGGESTIONS FROM EMPLOYEES are asked for on the Buffalo & Allegheny Division of the Pennsylvania R. R. It is announced that ideas which prove valuable will be paid for by the company. The general notice to employees containing the announcement describes what is desired in the way of suggestions as follows:

> Suggestions must contain ideas which will: Increase efficiency of operation; improve methods of operation; be beneficial from economical standpoint; increase safety and convenience of passengers and patrons of our company; increase patronage; promote safety of employees, or in any way promote the interests of the company, whether pertaining to improved mechanism, better office practice or other features.
>
> Suggestions may involve the use of new methods or the modification of old ones; may include the comfort or betterment of employees, but must not include personal complaints or antipathies.

THREE MEN WERE ELECTROCUTED on the tracks of the New York Central Railroad electric-traction zone, in New York City, April 29. A line crew of six men were replacing a pole between Spuyten Duyvil and Kingsbridge stations when a steel guy cable they were using came in contact with either the third rail or a high-tension feed wire. From the descriptions of the victims' burns it is probable that the latter contact was made. This view is strengthened by the physician's opinion that the men were instantly killed.

A CONFLAGRATION SWEPT BANGOR, ME., April 30, and caused a property loss variously estimated at from three to six million dollars. Reports state that 100 business buildings, 275 residences and 6 churches were destroyed in addition to the high school, public library and post-office. The burned district includes nearly half the business section and a portion of the better-class residential section of the town. The fire started at 4 p. m. near the corner of Broad and Summer Sts. on the west bank of the Kenduskeag stream, a tributary of the Penobscot River, and spread north along both banks of the stream covering an area nearly a mile long in a north and south direction and from a quarter to a half-mile wide. Some buildings were dynamited by the firemen in the hope of checking the fire, but without avail. The fire was not gotten under control until 11 p. m., after burning for seven hours, and the flames were not entirely extinguished until about 8 a. m. the following day (May 1).

NO LEGISLATION REGARDING LICENSING OF Engineers is likely to be enacted by the New York Legislature at the present session. The strong opposition manifested by the engineers of the state, at the hearings held by the Assembly committees having the McGrath and Hoff Bills in charge, appears to have had its effect in causing the committees to regard these bills unfavorably. The bill introduced in the Senate, framed on similar lines to the Hoff Bill, and referred to the Committee on Public Education, has also been strongly opposed by engineers, although no public hearing has been held. It is unlikely therefore that this bill will be reported. The delay in the legislative work resulting from the Albany Capitol fire has overwhelmed the Legislature with work, so that there is little chance of any legislation being enacted at the present session which is not backed by strong public demand.

Personals.

Mr. H. A. Hatch has been appointed Division Engineer, at Chanute, Kan., of the Atchison, Topeka & Santa Fe Ry.

Mr. Dennis J. Haggerty, Superintendent of Streets of Springfield, Mass., has resigned and will re-enter private business as a masonry contractor.

Mr. L. K. Sherman, M. Am. Soc. C. E., formerly Assistant Engineer of the Sanitary District of Chicago, has been appointed Assistant Chief Engineer of the same.

Mr. H. L. Handley, formerly Locating Engineer for the Greenbrier, Cheat & Elk R. R. of West Virginia, has taken a position as Engineer for the Yankee Fuel Co., at Yankee, N. Mex.

Mr. J. R. McColl, M. Am. Soc. M. E., of the engineering firm of Ammerman, McColl & Anderson, of Detroit, Mich., has been appointed Dean of the Engineering Department of the University of Detroit.

Mr. Carl Stradley, formerly Locating Engineer for the Oregon Short Line R. R., has been appointed Chief Engineer, with headquarters at Salt Lake City, Utah. Mr. Stradley succeeds Mr. William Aston, M. Am. Soc. C. E., who has resigned.

Mr. O. L. Dickeson, until recently Inspector of Transportation of the Chicago, Burlington & Quincy R. R., has been elected Vice-President of the White Pass & Yukon Route, which includes four small railways in Alaska and British Columbia. He will make his headquarters at Vancouver, B. C.

Mr. Frank W. Morse, General Manager of the Chicago & Alton R. R. and the Toledo, St. Louis & Western R. R., has been elected Vice-President of the same roads to succeed Mr. George H. Ross, who has resigned on account of ill-health. Mr. Morse will continue to have charge of operation and maintenance of the two roads.

Mr. Arthur P. Davis, M. Am. Soc. C. E., Chief Engineer of the U. S. Reclamation Service, was granted three-months' leave of absence on March 15 and is now in Russia, where he was called in consultation by Russian officials and engineers to advise on proposed irrigation projects in Russian Turkestan. It is expected that he will return by way of Egypt, arriving in Washington about June 15.

Mr. B. B. Greer, formerly Superintendent of Terminals at St. Louis, Mo., for the Chicago, Burlington & Quincy R. R., has been appointed Superintendent of the Hannibal Division, with headquarters at Hannibal, Mo. Mr. T. K. Knight has been appointed Assistant Superintendent of the Hannibal Division, with headquarters at St. Louis, Mo. The office of Superintendent of Terminals has been abolished and hereafter the St. Louis terminals will be operated as a part of the Hannibal Division.

Mr. Chas. J. Davidson, M. Am. Soc. M. E., has resigned as Chief Engineer of Power Plants of the Milwaukee Electric Ry. & Light Co., and as General Superintendent of the Milwaukee Central Heating Co., to engage in private practice of engineering as a partner of Mr. Fay Woodmansee, M. Am. Inst. E. E., at Chicago, Ill. Mr. Davidson was formerly Chief Engineer of the Sioux City Traction Co., of Sioux City, Iowa.

Mr. William J. Wilgus, M. Am. Soc. C. E., of New York City, has been awarded the Telford gold medal by the Institution of Civil Engineers of Great Britain for a paper on the Detroit River tunnels. Mr. Wilgus was formerly Vice-President in charge of construction of the New York Central R. R. and had general supervision of the New York City terminal improvements and the installation of electric power. He was Chairman of the Board of Supervising Engineers for the construction of the Detroit River tunnels.

Messrs. John Hays Hammond, Joseph A. Holmes, Director of the U. S. Bureau of Mines, and F. D. Ricketts, M.'s Am. Inst. M. E., have been selected a committee to see that an agreement is carried out between the U. S. Government and the Anaconda Copper Mining Co., by which the latter is to equip its smelters at Butte, Anaconda and Great Falls, Mont., with devices to prevent the emission of poisonous gases. The agreement is a compromise resulting from a suit by the Government against the copper company for damage done to the National forests by the smelter fumes.

The Pennsylvania R. R. announces the following changes and promotions: Mr. F. L. Sheppard, from General Superintendent of the New Jersey Division to General Superintendent of the West Jersey & Seashore R. R. and the Philadelphia & Camden Ferry Co.; Mr. J. T. Wallis, from Superintendent of Motive Power of the Erie Division and the Northern Central R. R. to Superintendent of Motive Power of the West Jersey & Seashore R. R. and the Philadelphia & Camden Ferry Co.; Mr. I. B. Thomas, from Master Mechanic of the Altoona shops to Superintendent of Motive Power of the Erie Division and the Northern Central R. R.; Mr. J. C. Mengel, from Master Mechanic of the West Philadelphia shops to Master Mechanic at Altoona; Mr. J. M. James, from Master Mechanic at Olean, N. Y., to Master Mechanic at West Philadelphia; Mr. J. M. Henry, from Master Mechanic at Sunbury, Pa., to Master Mechanic at Baltimore, Md., to Master Mechanic at Sunbury, Pa.; Mr. H. P. Meredith, Assistant Engineer of Motive Power, appointed Master Mechanic at Baltimore, Md.; Mr. C. L. McIlvaine, Assistant Engineer of Motive Power of the Erie Division and the Northern Central R. R., to Assistant Engineer of Motive Power, Office of the General Superintendent of Motive Power; Mr. C. D. Barrett, Assistant Master Mechanic at Wilmington, Del., to Assistant Engineer of Motive Power of the Erie Division and the Northern Central R. R., at Williamsport, Pa., and Mr. B. B. Milner, on special duty in the office of the Assistant to the General Manager, appointed Assistant Master Mechanic at Wilmington, Del.

Obituary.

J. C. Dailey, General Superintendent of the Utah lines of the Denver & Rio Grande R. R., at Salt Lake City, Utah, died in that city on April 4.

Alexander E. Brown, M. Am. Soc. M. E., President of the Brown Hoisting Machinery Co., of Cleveland, Ohio, died on April 26. A biographical sketch and portrait of Mr. Brown appears elsewhere in this issue.

Benton Lattin, a civil engineer with the Pennsylvania R. R., died at Ashtabula, Ohio, on May 2, after a very brief illness, from tuberculous meningitis. He was a civil engineering graduate of Cornell University in the class of 1907. He had been previously employed by the New York Tunnel & Terminal Co., the Custodis Chimney Construction Co. and the American Bridge Co. He will be remembered by many readers as a contributor to Engineering News.

Frank Pidgeon, Contracting Engineer, died at his home in Brooklyn, N. Y., on March 23. He was born in Saugerties, N. Y., in 1851. He started in business with his father, Frank Pidgeon, in connection with whom he built the Export Lumber Yards and made extensive improvements to the Union College property on Newton Creek. He built all the trestle work on the West Shore R. R., from Jones Point to Kingston, as well as the piers and abutments of the Kingston viaduct. He did considerable work at the Norfolk Navy Yard, built the seawall at the Soldiers' Home at Fortress Monroe, and did a large amount of dredging work for the U. S. Government. He was connected with municipal improvements throughout New York State and was contractor for many miles of state roads. He was often complimented for the durability of his roads. Mr. Pidgeon had been in poor health for two years previous to his death. [Obituary from Mr. Oscar Hasbrouch, Assoc. M. Am. Soc. C. E., Engineer for Holler & Shepard, Contractors, Rochester, N. Y.]

Engineering Societies.

COMING MEETINGS.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 15-18. Annual meeting at Chattanooga, Tenn. Secy., D. B. Sebastian, 721 La Salle Station, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
May 17. Semi-annual meeting at New York City. Secy., W. F. Allen, 24 Park Pl., New York City.

OHIO SOCIETY OF MECHANICAL, STEAM AND ELECTRICAL ENGINEERS.
May 18-19. Annual convention at Youngstown, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 23-25. Annual meeting at New York City. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

AIR BRAKE ASSOCIATION.
May 23-26. Annual convention at Chicago, Ill. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 23-26. Annual convention at Pittsburg, Pa. Secy., Richard Moldenke, Watchung, N. J.

INTERNATIONAL MASTER BOILERMAKERS' ASSOCIATION.
May 23-26. Annual convention at Omaha, Neb. Secy., H. D. Vought, 62 Liberty St., New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 29-June 2. Annual convention at New York City. Secy., T. C. Martin, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 30-June 2. Annual convention at Pittsburg, Pa. Secy., Calvin W. Rice, 29 West 39th St., New York City.

AMERICAN WATER WORKS ASSOCIATION.
June 6-10. Annual convention at Rochester, N. Y. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN INSTITUTE OF MINING ENGINEERS.
June 6. Annual convention at Glen Summit Springs Hotel, Luzerne Co., Pa. Secy., Joseph Struthers, 29 West 39th St., New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 13-16. Annual convention at Chattanooga, Tenn. Secy., Charles W. Hunt, 220 West 57th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-16. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 19-21. Annual convention at Atlantic City, N. J. Secy., Jos W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19-23. Annual convention at Boston, Mass. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 21-24. Semi-annual meeting at Chicago, Ill. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 26-30. Annual convention at Chicago, Ill. Secy., Ralph W. Pope, 33 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 27-29. Annual meeting at Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-July 1. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN CHEMICAL SOCIETY.
June 28-July 1. Annual convention at Indianapolis, Ind. Secy., Charles L. Parsons, Durham, N. H.

LEAGUE OF AMERICAN MUNICIPALITIES.—The 15th annual convention will be held in Atlanta, Ga., Oct. 4-6. Among the topics for discussion will be municipal insurance, taxation of personal properties, commission government, garbage collection and disposal and public service franchises.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At the meeting of May 3 in New York City, Mr. John P. Hogan's paper on "Sinking a Wet Shaft" was presented for discussion. This paper was printed in the March "Proceedings."

AMERICAN RAILWAY ASSOCIATION.—At the spring session in New York City on May 17, reports will be presented by the committees on transportation, maintenance, relations between railroads, safe transportation of explosives and other dangerous articles and on electrical working.

DETROIT ENGINEERING SOCIETY.—At the annual meeting, held April 21, officers for the coming year were elected as follows: President, Ralph Collamore; Vice-Presidents, Charles Y. Dixon (Amherstburg, Ont.) and Geo. H. Fenkell; Secretary-Treasurer, Frederick H. Mason, 612 Moffat Bldg., Detroit, Mich.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—All technical sessions of the spring meeting in Pittsburg, Pa., May 30-June 2, will be held in Carnegie Institute, which is conveniently near the society's headquarters in the Hotel Schenley. The mechanical engineering of cement manufacture will be the subject of the first of the technical sessions, which will be held Wednesday morning, May 31. In the afternoon a trip will be made to the works of the Universal Portland Cement Co., at Universal, Pa., with a stop at East Pittsburg to allow those who desire to visit the plants of the Westinghouse Electric & Mfg. Co. and the Westinghouse Machine Co. The second technical session, at which papers on machine shop practice will be presented, is scheduled for the evening of the same day. The professional session of Thursday morning will deal with miscellaneous topics and will be as brief as possible, in order to leave ample time for an excursion up the Monongahela River, including a visit to the National Tube Co.'s works at McKeesport. A reception and informal dance will take place in the evening at the convention headquarters. The concluding professional session, when steel works practice will be the subject for consideration, will take place on Friday morning. An inspection trip to the Mesta Machine Co.'s works at Homestead is planned for Friday afternoon, and the convention will close that evening with a smoker and entertainment given by the Engineers' Society of Western Pennsylvania at their rooms in the Oliver Building. A ladies' committee, of which Mrs. Chester B. Albree is Chairman, will care for the pleasure of the guests of the Society.

Papers to be presented at the different sessions are announced as follows:

Cement manufacture, May 31.—"Edison Roll Crusher," W. H. Mason, Superintendent of the Edison Portland Cement Co., Stewartsville, N. J.; "Some Problems of the Cement Industry," Walter S. Landis, Associate Professor of Metallurgy at Lehigh University.

Machine shop practice, May 31.—"Assembling Small Interchangeable Parts," John Calder, Manager of the Remington Typewriter Works, Ilion, N. Y.; "Methods of Assembling Small and Intricate Parts," Malcolm Ellis, Ellis Adding-Typewriter Co., Newark, N. J.; "The Design of Milling Cutters and Their Efficiency," A. L. De Leeuw, Mechanical Engineer, Cincinnati Milling Machine Co., Cincinnati, Ohio.

Miscellaneous, June 1.—"Stresses in Tubes," Reid T. Stewart, Professor of Mechanical Engineering, University of Pittsburg; "The Purchase of Coal on the Heat Unit Basis," Dwight T. Randall, Fuel Engineering Department, Arthur T. Little, Inc., Boston, Mass.; "Energy and Pressure Drop in Compound Steam Engines," F. E. Cardullo, Department of Mechanical Engineering, New Hampshire College of Agriculture and the Mechanic Arts; "A Pressure Recording Indicator for Punching Machinery," Gardner C. Anthony, Dean of the Engineering School, Tufts College.

Steel works practice, June 2.—"The Commercial Application of the Turbine Turbo-Compressor," R. H. Rice, General Electric Co., West Lynn, Mass.; "Hydraulic Forging Presses and Blowing Engines."

There will also be a session on Gas Power, with papers to be announced later.